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# TEXAS' SENATE BILL 5 LEGISLATION FOR REDUCING POLLUTION IN NON-ATTAINMENT AND AFFECTED AREAS:

Report for the
TERP Advisory Board Meeting


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**ENERGY SYSTEMS LABORATORY**

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# EXECUTIVE SUMMARY

This report outlines the Energy Systems Laboratory's responsibilities in Senate Bill 5, accomplishments to date, recommendations to the TERP Advisory Group, and problems encountered to date and what is needed to fulfill the Laboratory's responsibilities. A section of this report also discusses the technology of reporting and verifying emissions reductions from the energy used in buildings, and presents an overview of the technologies for reducing energy use in buildings.

## 1.1 Energy Systems Laboratory's Responsibilities for Senate Bill 5.

Texas Senate Bill 5 has outlined the following responsibilities for the Energy Systems Laboratory:

- Section 386.205 - Evaluation Of State Energy Efficiency Programs.
- Sec. 388.003. Adoption Of Building Energy Efficiency Performance Standards.
- Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.
- Sec. 388.007. Distribution Of Information And Technical Assistance.
- Sec. 388.008. Development Of Home Energy Ratings.

This report outlines the tasks that have been accomplished by the Laboratory since September 1st, 2001, and discusses recommendations, and problems encountered.

## 1.2 Accomplishments

Since September 2001, the Energy Systems Laboratory has been able to accomplished the following:

- Laboratory's Senate Bill 5 Web Site operational
- Created Senate Bill 5 Stakeholders Group
- Builder's Guide (Version 003) published
- Self-Certification Form (Version 1.3) published
- R-6 versus R-8 Flexible Duct Issue resolved
- Created IECC/IRC code-traceable simulation test suite
- Implementation Date support to Senator Brown
- Provide Training Sessions
- Responding to about 40 to 60 calls per week
- Submitted code amendment review for NCTCOG
- Requested by NCTCOG to approve Energy Star as above code
- Requested by EPA to approve Energy Star as above code
- Requested by Florida Solar Energy Center to approve EnergyGauge USA as above code
- Requested by EPA to approve Energy Star as above code for Texas
- Working toward a standard DOE-2 input file for code compliance testing
- Delivered Senate Bill 5 Sessions at Hot and Humid Conference
- Delivered 'Building Energy Codes and Technologies" at the TCET Symposium for Reducing Emissions in Texas, May 21, 2002, Houston, Texas
- Development of an analysis plan to report energy reductions and link to emissions reductions

This report discusses each of these accomplishments, and how they are relevant to Senate Bill 5.

## 1.3 Recommendations

The Energy Systems Laboratory recommends the following measures to improve the effectiveness of Senate Bill 5:

- Refinement of the analysis method for reporting emissions reductions.
- Identification of health issues associated with improved energy use.
- Development of "Showcase houses on wheels".
- Focus on hard-to-reach areas
- Study the impact of improving the efficiency of manufactured housing
- Study the impact of including appliance efficiency standards.

- Capture and document the energy savings in Texas LoanSTAR and Rebuild America programs currently in place.

## 1.4 Technology of Reporting and Verifying Emissions Reductions From Energy Used in Buildings

### 1.4.1 Procedures for Calculating Electricity Reductions

Residential Buildings. The proposed methodology to accomplish this for residential buildings is composed of several procedures that will calculate and verify savings using several different sources of information. These procedures include:

- The calculation of electricity savings and peak demand reductions from the implementation of the IECC 2001 in new residences in non-attainment and affected counties as compared against 1999 housing characteristics (IECC 2001 residential emissions reductions) using calibrated simulation.
- A cross-check of the calculated energy use against the published average energy use found in the USDOE's Residential Energy Characteristics Survey (RECS 1999)
- A cross-check of electricity savings using a utility bill analysis method.
- A cross-check of construction data using on-site visits.

Commercial Buildings. The proposed methodology to accomplish this for commercial buildings is also composed of several procedures that will calculate and verify savings using several different sources of information. These procedures include:

- The calculation of electricity savings and peak demand reductions from the implementation of the IECC 2001 in commercial buildings in non-attainment and affected counties as compared against 1999 commercial building characteristics (IECC 2001 commercial emissions reductions) using calibrated simulation.
- A cross-check of the calculated energy use against the published average energy use found in the USDOE's Commerical Building Energy Characteristics Survey (CBECS 1995)
- A cross-check of electricity savings using a utility bill analysis method.
- A cross-check of construction data using on-site visits.

Renewables Applied to Buildings. The application of renewable energy systems in buildings are also addressed by the 2000 IECC/IRC. To account for the energy savings from these activities, procedures similar to new construction will be applied.

### 1.4.2 Procedures for Calculating Ozone Reductions.

In this report two types of calculation procedures are discussed in this report in regards to the estimation of emissions reductions from buildings: data requirements for the calculation of annual NOx reductions, and data requirements for hourly ozone modeling. The first procedure requires annual, countywide kWh reductions and peak kW reductions. The second procedure requires data and calculations from several state agencies, university labs and private entities. The procedure begins with simulated, hourly, county-wide electricity savings from the implementation of the IECC/IRC to residential, commercial and industrial facilities, followed by the calculation of the electrical power production at the power plant using the appropriate grid model. The hourly, plant-specific power generation is then linked to hourly, TNRCC-measured pollutants for each plant to obtain the hourly, NOx, VOC and other pollutants associated with the power production at the time of the simulation. These hourly NOx and VOC are then merged together with other sources of NOx and VOC and fed into an hourly photochemical model along with the prevailing weather conditions to allow for the calculation of the ozone pollution (i.e., Ozone day or August-September 2000 Episode day) to determine the reduction in ozone. Although this description is overly-simplified, four groups must work closely together to accomplish this task. These are the Laboratory, TNRCC, ERCOT and the UT Atmospheric Sciences Group. This group can put a solid, defensible set of ozone reductions forward to the US EPA. Additional groups may need to be added to this core group to assure all building-related savings are accounted for in the modeling, including: SECO, PUC, SERC, SPP and WSCC. The legislature could address how to allow these data to be acquired as truly needed. Deregulation of the electric utilities is also complicating the acquisition of needed data.

## 1.5 Technology of Reducing Energy Used in Buildings

Adoption of the 2000 IECC/IRC has allowed the state of Texas to define the minimum energy performance for new buildings and for existing buildings that are remodeled. In this report technologies are briefly reviewed that can have a substantial impact on delivering above-code building performance for residential, commercial and industrial buildings in Texas Buildings. In general for residential buildings, the 2000 IECC/IRC provides prescriptive measures for each climate zone in Chapters 5 and 6 to assure that new construction meets a minimum, predictable energy use. A residential performance path is provided in Chapter 4. Commercial buildings are addressed by minimum prescriptive measures in Chapter 8 of the 2000 IECC/IRC, or by minimum performance measures using ASHRAE Standard 90.1 1999, which is referenced by Chapter 7.

Technologies for reducing energy use in buildings is reviewed in this report, including the following technologies:

- Building Envelope.
- Appliances
- Heating/Cooling Systems
- Low NOx Technologies for Building Systems
- Industrial
- Other: Restaurants and Grocery Stores
- Renewables
- Thermal comfort and Indoor Air Quality

## 1.6 Problems and Needs

### 1.6.1 Industry concerns

The key roadblock has been the lack of funding. This ripples through all activities and creates situations where the Laboratory has to focus only on emergencies. In general, the cooperation and enthusiasm of all parties (including the builders/builder groups, manufacturers, public interest groups and other agencies) has been very understanding and supportive. This lack of adequate funding has seriously slowed the Laboratory’s progress in making the code adaptation a smooth process in Texas.

Cost and health impacts from the adoption of the codes have also arisen as a major issue. Cost impact needs to be studied and documented. Likewise, builders and homeowners are concerned about the health issues of tight buildings. The Laboratory needs to demonstrate and make these methods available to Texas builders.

### 1.6.2 Technology concerns

The Laboratory has initiated meetings with ERCOT, and the CEER at the University of Texas to identify the technology needed to accurately measure, model and predict ozone reductions from implementation of Senate Bill 5. To accomplish this, four groups must work closely together. These are the Laboratory, TNRCC, ERCOT and the UT Atmospheric Sciences Group. This group can put a solid, defensible set of ozone reductions forward to the US EPA. Additional groups may need to be added to this core group to assure all savings are accounted for in the modeling, including: SECO, PUC, TxDOT, SERC, SPP and WSCC. The legislature could address how to allow these data to be acquired as truly needed. Deregulation of the electric utilities is also complicating the acquisition of needed data.

TABLE OF CONTENTS

TABLE OF FIGURES

# 2 Introduction

## 2.1 Background

Thirty-eight counties in Texas have been designated by the EPA as either non-attainment or affected areas. These areas are shown on the map in Figure 1, as non-attainment (dark-shaded), and affected (shaded). The sixteen counties designated as non-attainment counties include: Brazoria, Chambers, Collin, Dallas, Denton, El Paso, Fort Bend, Hardin, Harris, Jefferson, Galveston, Liberty, Montgomery, Orange, Tarrant, and Waller counties. The twenty-two counties designated as affected counties include: Bastrop, Bexar, Caldwell, Comal, Ellis, Gregg, Guadalupe, Harrison, Hays, Johnson, Kaufman, Nueces, Parker, Rockwall, Rusk, San Patricio, Smith, Travis, Upshur, Victoria, Williamson, and Wilson County.

These counties represent different areas of the state that have been categorized into the different climate zones by the 2001 IECC[1] as shown in Figure 2, namely, climate zone 5 or 6 (i.e., 2,000 to 2,999 $HDD_{65}$) for the Dallas-Ft. Worth and El Paso areas, and climate zones 3 and 4 (i.e., 1,000 to 1,999 $HDD_{65}$) for the Houston-Galveston-Beaumont-Port Author-Brazoria area. Also shown on Figure 2 are the locations of the various weather data sources, including the seventeen Typical Meteorological Year (TMY2) (NREL 1995), and four Weather Year for Energy Calculations (WYEC2) (Stoffel 1995) weather stations, as well as the forty-nine National Weather Service weather stations, (NWS) (NOAA 1993).

To no surprise, these thirty-eight counties represent some of the most populated counties in the state, and contained 13.9 million residents in 1999, which represents 69.5% of the state's 20.0 million total population (U.S. Census 1999). As shown in Figure 3, three of these counties (i.e., Harris, Dallas, and Tarrant), are non-attainment counties. The fourth county, Bexar county, is classified as an affected county. These four counties contain 8.0 million residents, or 40.0% of the state's total population. In the rankings of the remaining counties it is clear to see that the most populated counties also represent the majority of the non-attainment regions.

In Figure 4 the total housing units trends in the non-attainment and affected counties is shown to closely follow the county populations, with Harris, Dallas, Tarrant, and Bexar counties containing 3.2 million housing units, or 40.0% of the state's total 8.0 million households (U.S. Census 1999). However, in Figure 5 the 1999 residential building permit activity differs from the population and total housing unit trends, with the most activity occurred in Harris county (25,862 units), followed by significantly less construction in the five counties in the 10,000 to 15,000 unit range, including Dallas, Travis, Bexar, Collin and Tarrant counties. These six counties represented 88,833 housing starts, or 71% of the total 125,100 residential building permits in the 38 counties classified as non-attainment or affected by the EPA.

Also of interest in Figure 5 is the significant number of new multi-family units in the counties with the largest number of building permits. In the six largest counties (i.e., Harris, Dallas, Travis, Bexar, Collin and Tarrant) there were 34,038 new multi-family units, or 38% of the 88,833 housing starts in these counties. The map in Figure 6 shows these fast growing areas to be primarily in four metropolitan areas: the Houston area containing the fastest growing county (Harris county), the Dallas-Ft.Worth area containing four of the six counties (Dallas, Collin, Tarrant, and Denton), Travis county in the Austin metropolitan area, and Bexar county in the San Antonio area.

[1] The "2001 IECC" notation is used to signify the 2000 IECC (IECC 2000) as modified by the 2001 Supplement (IECC 2001), published by the ICC in March of 2001, as required by Senate Bill 5.

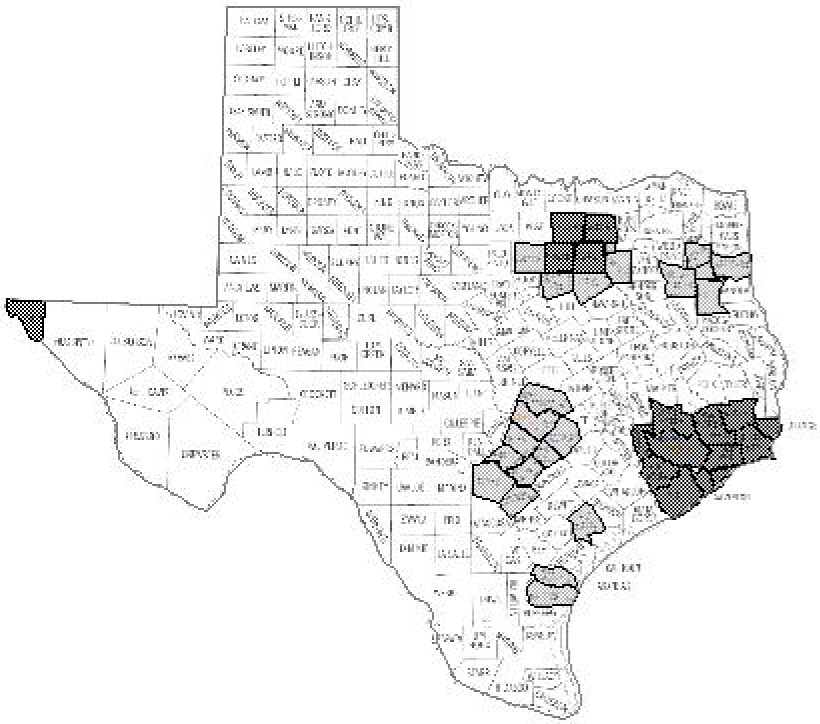

Figure 1: EPA Non-attainment (dark shade) and affected counties (light shade).

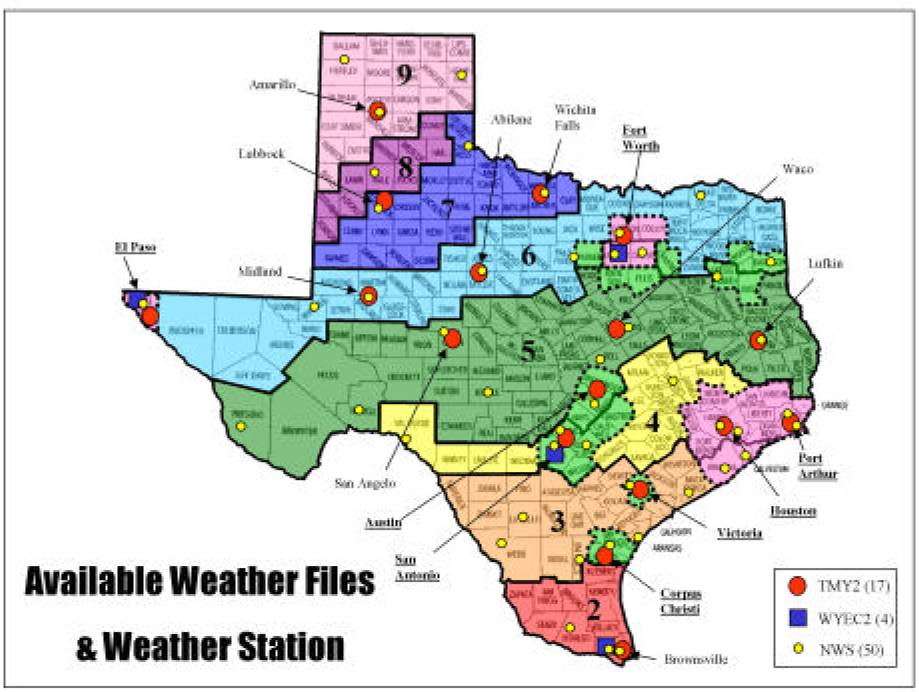


Figure 2: Available NWS, TMY2 and WYEC2 weather files compared to IECC weather zones for Texas.

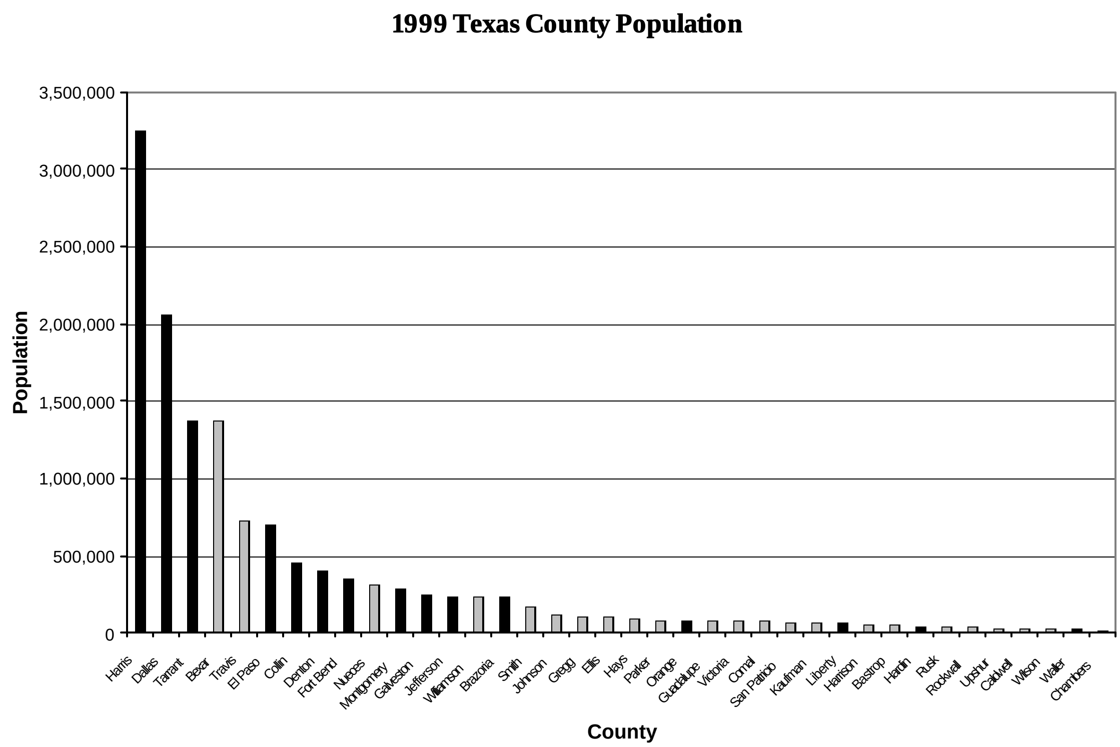


Figure 3: 1999 Texas county population for non-attainment (dark shade) and affected (light shade) counties (Source: U.S. Census)

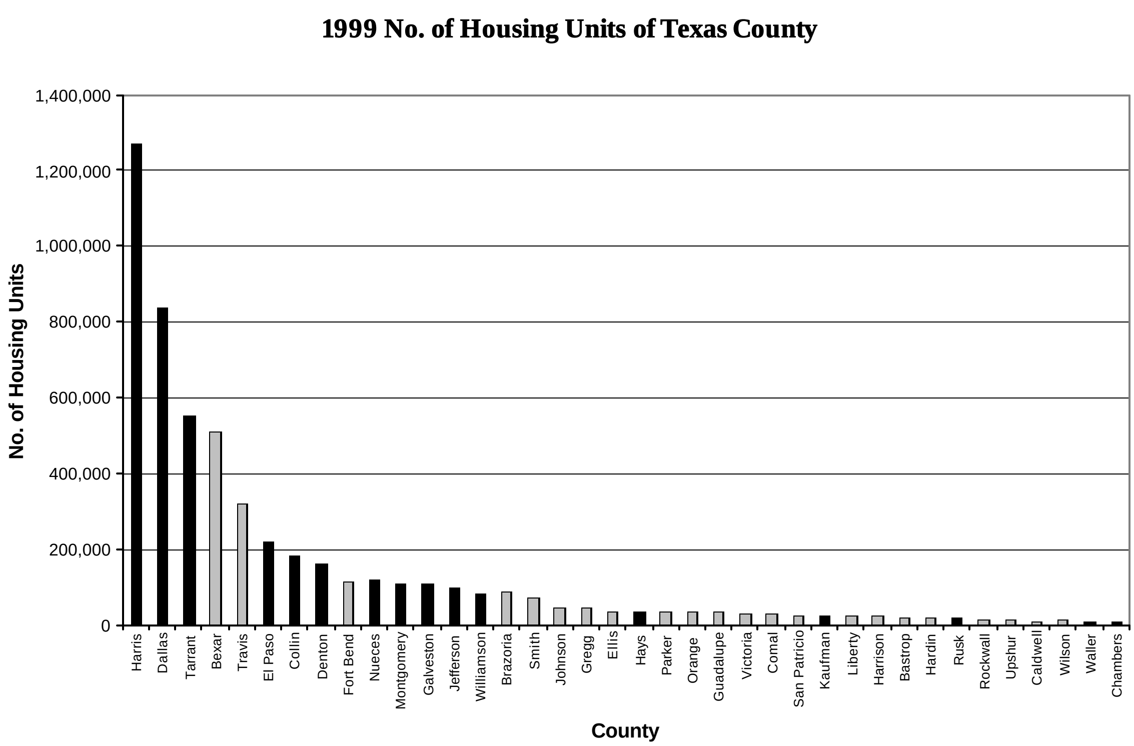


Figure 4: 1999 Housing Units by County (Source: RECenter 2002).

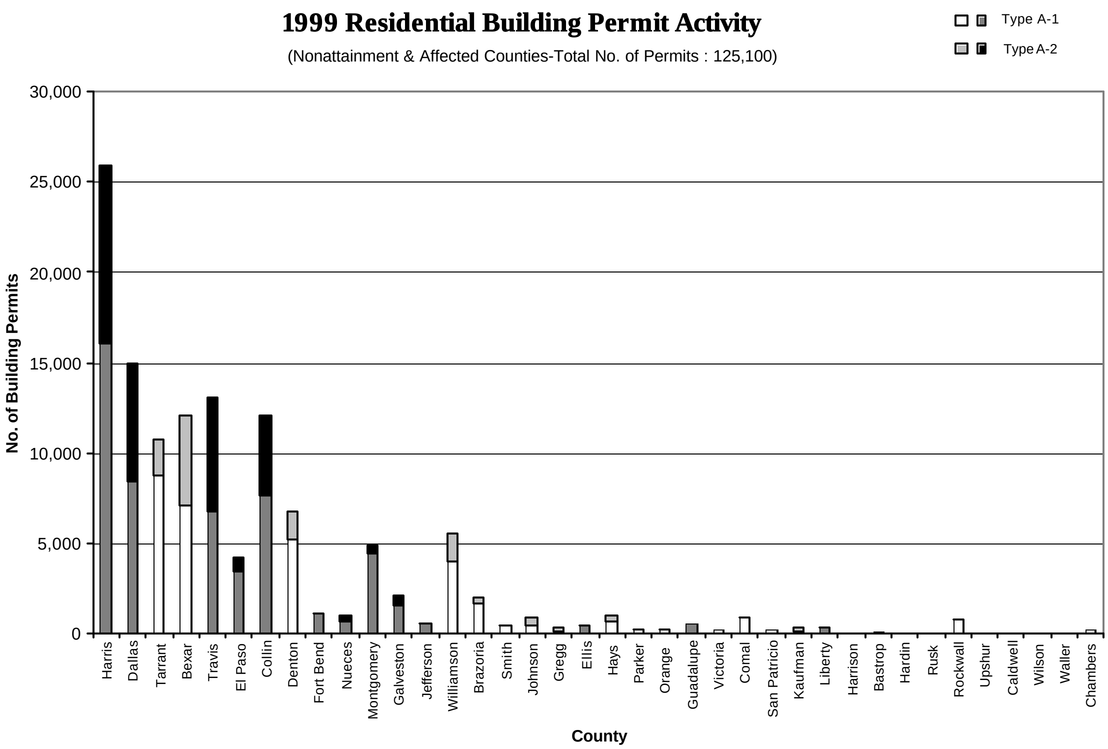


Figure 5: 1999 Residential Building Permits by County (Source: Real Estate Center, TAMU).

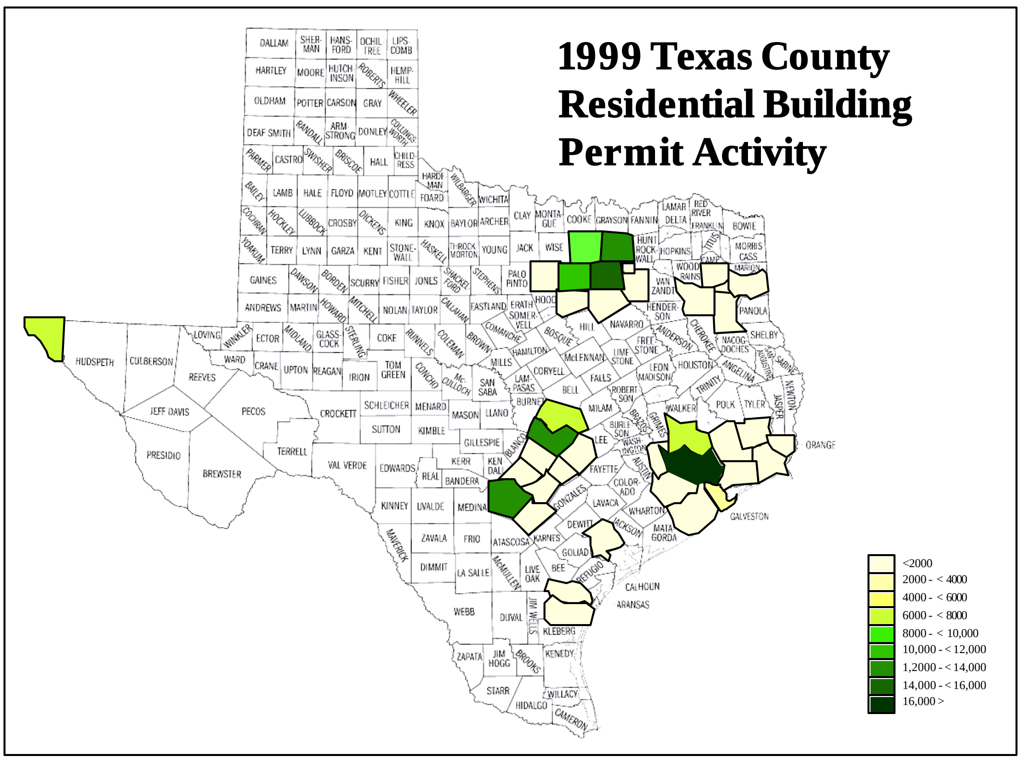


Figure 6: Map of 1999 Residential Building Permits by County (Source: Real Estate Center, TAMU).

## 2.2 Energy Systems Laboratory's Responsibilities for Senate Bill 5.

Texas Senate Bill 5 has outlined the following responsibilities for the Energy Systems Laboratory (ESL):

- Sec. 386.205 - Evaluation Of State Energy Efficiency Programs.
- Sec. 388.003. Adoption Of Building Energy Efficiency Performance Standards.
- Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.
- Sec. 388.007. Distribution Of Information And Technical Assistance.
- Sec. 388.008. Development Of Home Energy Ratings.

In the following sections each of these tasks is further described.

### 2.2.1 Section 386.205 - Evaluation Of State Energy Efficiency Programs.

In this section of Senate Bill 5, the Laboratory is instructed to assist the Texas Public Utilities Commission (PUC) and provide an annual report that quantifies by county, the reductions of energy demand, peak loads, and associated emissions of air contaminants achieved from the programs implemented under this subchapter and from those implemented under Section 39.905, Utilities Code (i.e., Senate Bill 7).

### 2.2.2 Sec. 388.003. Adoption Of Building Energy Efficiency Performance Standards.

This section of Senate Bill 5 adopts the energy efficiency chapter of the 2000 International Residential Code (IRC 2000) as an energy code for single family residential construction, and the 2000 International Energy Conservation Code (IECC 2000, including the 2001 supplement) for all other residential, commercial and industrial construction in the state. It requires that municipalities establish procedures for administration and enforcement, and ensure that code-certified inspectors perform inspections.

Senate Bill 5 Provides that local amendments, in non-attainment areas and affected counties, may not result in less stringent energy efficiency requirements. The Laboratory is to review local amendments, if requested, and submit annual report of savings impacts to TNRCC. The Laboratory is also authorized to collect fees for certain of its tasks in Secs. 388.004, 388.007 and 388.008.

### 2.2.3 Sec. 388.004. Enforcement Of Energy Standards Outside Of Municipality.

For construction outside of the local jurisdiction of a municipality, Senate Bill 5 provides for a building to comply if:

a) a building certified by a national, state, or local accredited energy efficiency program shall be considered in compliance;

b) a building with inspections from private code-certified inspectors using the energy efficiency chapter of the International Residential Code or International Energy Conservation Code shall be considered in compliance; and

c) a builder who does not have access to either of the above methods for a building shall certify compliance using a form provided by the Laboratory, enumerating the code-compliance features of the building.

### 2.2.4 Sec. 388.007. Distribution Of Information And Technical Assistance.

In this section of Senate Bill 5, the Laboratory is required to make available to builders, designers, engineers, and architects code implementation materials that explain the requirements of the International Energy Conservation Code and the energy efficiency chapter of the International Residential Code. Senate Bill 5 authorizes the Laboratory to develop simplified materials to be designed for projects in which a design professional is not involved. It also a authorizes the Laboratory to provide local jurisdictions with technical assistance concerning implementation and enforcement of the 2000 International Energy Conservation Code and the energy efficiency chapter of the 2000 International Residential Code.

### 2.2.5 Sec. 388.008. Development Of Home Energy Ratings.

Senate Bill 5 requires the Laboratory to develop a standardized report format to be used by providers of home energy ratings (HERs). It requires the form to be designed to give potential buyers information on a structure's energy performance, including certain equipment. Senate Bill 5 requires the Laboratory to establish a public information program to inform homeowners, sellers, buyers, and others regarding home energy ratings. It also requires the home energy ratings program to be implemented by September 1, 2002 .

## 3 ACCOMPLISHMENTS

Since September 2001, the Energy Systems Laboratory has been able to accomplished the following:

- ESL's Senate Bill 5 Web Site operational
- Created Senate Bill 5 Stakeholders Group
- Builder's Guide (Version 003) published
- Self-Certification Form (Version 1.3) published
- R-6 versus R-8 Flexible Duct Issue
- Implementation Date
- Provide Training Sessions
- Responding to about 40 to 60 calls per week
- Submitted code amendment review for NCTCOG
- Requested by NCTCOG to approve Energy Star as above code
- Requested by EPA to approve Energy Star as above code
- Requested by Florida Solar Energy Center to approve EnergyGauge USA as above code
- Request to approve AEC's REMRate as above code
- Working toward a standard DOE-2 input file for code compliance testing
- Delivered Senate Bill 5 Sessions at Hot and Humid Conference
- Delivered 'Building Energy Codes and Technologies" at the TCET Symposium for Reducing Emissions in Texas, May 21, 2002, Houston, Texas
- Development of an analysis plan to report energy reductions and link to emissions reductions

### 3.1 Web Site operational: eslsb5.tamu.edu

The Laboratory has established a Senate Bill 5 web page (i.e., eslsb5.tamu.edu), where information is provided to builders, code officials, and homeowners about Senate Bill 5, including: the Builder's prescriptive compliance form (B&W or color PDF), the Builder's self-certification form, the Laboratory's letter regarding the R8 flexible duct issue, information about the Laboratory's communications to the Texas Legislature, news articles, and related contacts. Figure 7 illustrates the Laboratory's Senate Bill 5 web page.

## 3.2 Created Senate Bill 5 Stakeholders Group

The Laboratory created a Senate Bill 5 Stakeholders Group consisting of manufacturers, public interest groups, builders, utilities, and Federal, State and Local government agencies. These Stakeholders meetings have provided the Laboratory with valuable input on how to best proceed with difficult issues that have had to be addressed in the first year of Senate Bill 5. Additional information about the Senate Bill 5 Stakeholders Group can be found on the Laboratory's web page.

## 3.3 Builder's Guide (Version 003) published

The Laboratory has produced a simplified Builder's Guide that provides builders with three prescriptive paths for each climate zone in Texas. This guide is available on the Laboratory's web site for downloading as a PDF file (i.e., eslsb5.tamu.edu). Six thousand color copies of the Builder's Guide have also been printed and laminated to be distributed to builders to code officials to help simplify the implementation of the IECC. An example copy of the Builder's Guide is provided in the Appendix, Figure 29 and Figure 30.

## 3.4 Self-Certification Form (Version 1.3) published

The Laboratory has developed self-certification form for code compliance for residential buildings in unincorporated areas that is available for downloading as a PDF file at the Laboratory's web site (i.e., eslsb5.tamu.edu). An example of the self-certification form has been provided in the Appendix, Figure 31 and Figure 32. This two-page form provides a simplified check list for a builder to use to self-certify that they are compliant with the 2000 IECC/IRC (including the 2001 Supplement).

## 3.5 R-6 versus R-8 Flexible Duct Issue

In March of 2002 the Laboratory issued a technical memo regarding the use of R-6 flexible duct insulation instead of R-8 flexible insulation:

"The International Energy Conservation Code (IECC) of 2001 requires that R8 flexible duct be used in place of lower R-rated insulated duct, when ducts are in unconditioned space. Although R6 duct is widely and economically available, R8 insulated flexible duct is not at this time. Limited Supplies are available from one manufacturer but not in the quantities needed to satisfy the requirements for homes in municipal areas.

Chapter 11 of the International Residential Code (IRC) specifically allows R5 or higher in homes with up to 15% window to wall area. The IECC requires R8 for above 15% window to wall area. Situations where code inspectors have not allowed R6 duct in housing where the window to wall area is under 15% have been reported, undoubtedly due to confusion and inadequate training.

Technically, R6 insulated flexible duct causes minimal decrease in efficiency except when used in unconditioned attics. Use of R6 duct will result in a few percent loss of efficiency for the cooling system. Improper installation of either R6 or R8 that causes leakage will result in a much greater loss of system efficiency."

This memo was the basis for the postponement of the use of R8 flexible duct (extended until February 1, 2003). A copy of Senator Brown's letter is provided in the Appendix in Figure 33, Figure 34 and Figure 35. A copy of this letter is also posted on the Laboratory's Senate Bill 5 web site.

## 3.6 Implementation Date

At the first Senate Bill 5 stakeholder's meeting, the Laboratory was asked to help resolve the issue regarding the implementation date for compliance with Senate Bill 5. The Laboratory issued a technical memo recommending a delay, in accordance with a memo regarding legislative intent from Senator Brown. The Texas Attorney General then ruled that the start date was to be September 1st, 2001.

3.7 Provide Training Sessions

The Laboratory has provided (29) IECC/IRC code training workshops at the following locations in Texas (Supported under State Energy Program DOE funding through SECO):

•Austin (2)
•Bonham
•Galveston
•Longview
•Lubbock
•McAllen
•San Antonio
•Corpus Christi (2)
•Victoria
•Abilene
•El Paso
•Amarillo
•Laredo
•Houston
•College Station (4)
•Kerrville
•Beaumont
•San Angelo
•Tyler
•Dallas

3.8 Responding to about 40 to 60 calls per week

The Laboratory responds to about 40 to 60 phone calls per week, which include questions about the IECC/IRC from Builders, HVAC Contractors, Window Manufacturers, Door Manufacturers, Duct Manufacturers, code officials, and homeowners. A database is being established to track questions and responses. A frequently asked questions (FAQ) feature is also being established for the Laboratory's Senate Bill 5 web page.

3.9 Submitted code amendment review for NCTCOG, including Energy Star as above code.

The Laboratory was asked by the North Central Texas Council of Governments to review selected amendments to the 2000 IECC/IRC, including the use of Energy Star as an alternative compliance path to the 2000 IECC/IRC. The amendments submitted to the Laboratory and the Laboratory's response are provided in the appendix. The request to approve the EPA's Energy Star program is discussed in the next section.

3.10 Requested by EPA to approve Energy Star as above code for Texas

The Laboratory was requested to approve the Energy Star program as "above code" for Houston. The Laboratory reviewed the Energy Star program, including the computer simulation used by the EPA[2]. The initial review precluded a blanket approval of the Energy Star program. The Laboratory also reviewed the newly revised Building Option Packages (BOPs) for Houston and Dallas. Following the review, discussions were then held with the EPA, ICF, the International Code Council (ICC), USDOE, PNNL, NREL and LBNL to determine how a code-traceable simulation could be developed and reviewed by experts at the USDOE's National Labs. Following the discussions the Laboratory then developed a code-traceable DOE-2 input file, and tested the Energy Star BOPs for Houston and Dallas.

Preliminary tests have shown that the Energy Star BOPs comply with the IECC Chapter 4 performance method after revisions[3]. Based on these preliminary results the Laboratory is working with Senator Brown's staff to determine how Energy Star can be approved as an alternative to the IECC/IRC.

[2] This computer analysis for the Energy Star program is based on DOE-2.1e, ver. 121 simulations, which are performed by ICF Consulting, Washington, D.C., under contract to the U.S.E.P.A.
[3] These revisions include: mandating SHGC < 0.40 for HDD < 3,500, double pane windows, referencing window area to wall area, and revising the footnotes on the BOPs to comply with the IECC/IRC.

3.11 Requested by Florida Solar Energy Center to approve EnergyGauge USA as above code

The Laboratory was also requested by the Florida Solar Energy Center (FSEC) to approve their EnergyGauge USA as an above code simulation program. The Laboratory is working with FSEC to resolve this request. It is anticipated that the code-traceable DOE-2 software will be used in a similar fashion to testing the Energy Star BOPs.

3.12 Request to approve REMRate as above code

The Laboratory was also requested by the Architectural Energy Corporation, Boulder, Colorado, to approve their REMRate software as an above code simulation program. The Laboratory is working with AEC to resolve this request. It is anticipated that the code-traceable DOE-2 software will be used in a similar fashion to testing the Energy Star BOPs.

3.13 Working toward a standard input file for code compliance testing

The Laboratory has developed a code-traceable DOE-2 input file for calculating energy savings and demand reductions from implementation of the IECC/IRC statewide. These simulations are needed for analyzing the energy savings from proposed municipality code amendments, and annual calculation of IECC statewide savings.

3.14 Delivered Senate Bill 5 Sessions at Hot and Humid Conference

To help foster technology transfer in Houston, the Laboratory worked closely with the Planning Committee for the 13th Symposium on Improving Building Systems in Hot and Humid Climates to include a plenary session and a panel session on Senate Bill 5. The 13th Symposium was held in Houston on May 20 – 22, 2002 and was well attended. The invited plenary speaker on May 20th was Commissioner Ralph Marquez, who spoke about the pollution problems in Houston and how Senate Bill 5 was created to help address these problems. The Senate Bill 5 panel session included two papers[4], and three additional presentations[5].

3.15 Delivered 'Building Energy Codes and Technologies" at the TCET Symposium for Reducing Emissions in Texas, May 21, 2002, Houston, Texas.

The Laboratory was also asked to develop and deliver panel on Building Energy Codes and Technologies for the May 21st, 2002 Symposium on Technology for Reducing Emissions in Texas, presented by the Texas Council on Environmental Technology, in cooperation with the Texas Natural Resources Conservation Commission, which was also presented in Houston. This panel was composed of Dr. David Claridge, ESL, Dr. Charles Culp, ESL, Mr. Mani Palani, UT Health Science Center, and John Hoffner, Conservation Services Group.

3.16 Development of an analysis plan to report energy reductions and link to emissions reductions

The Laboratory has initiated the development of several analysis plans to report the energy reductions from the implementation of the IECC/IRC to the TNRCC. The first procedure requires annual, countywide kWh reductions and peak kW reductions. The second procedure requires data and calculations from several state agencies, university labs and private entities. The second plan is being developed in cooperation with the

[4] The papers published in the Proceedings include: Haberl, J., Culp, C., B.Yazdani, T.Fitzpatrick, D.Turner. 2002. "An Introduction to Texas Senate Bill 5", Proceedings of the Thirteenth Symposium on Improving Building Systems in Hot and Humid Climates, Texas A&M University, Houston, Texas, and Haberl, J., Culp, C., B.Yazdani, T.Fitzpatrick, D.Turner. 2002. "Texas' Senate Bill 5 Legislation for Reducing Pollution in Non-attainment Areas: Procedures for Measuring Pollution Reduction from the Adoption of the International Energy Conservation Code (IECC/IRC 2001)", Proceedings of the Thirteenth Symposium on Improving Building Systems in Hot and Humid Climates, Texas A&M University, Houston, Texas.
[5] The additional presentations include an overview of Senate Bill 5 by Bill Jordon, TNRCC, a report on the PUC's efforts towards compliance with Senate Bill 5 by Jess Totten, PUC, and a report by Ken Donohoo from ERCOT.

Center for Energy and Environmental Resources (CEER) at the University of Texas, the Electric Reliability Council of Texas (ERCOT), and the Texas Public Utilities Commission (PUC). This plan is described in detail later in this report.

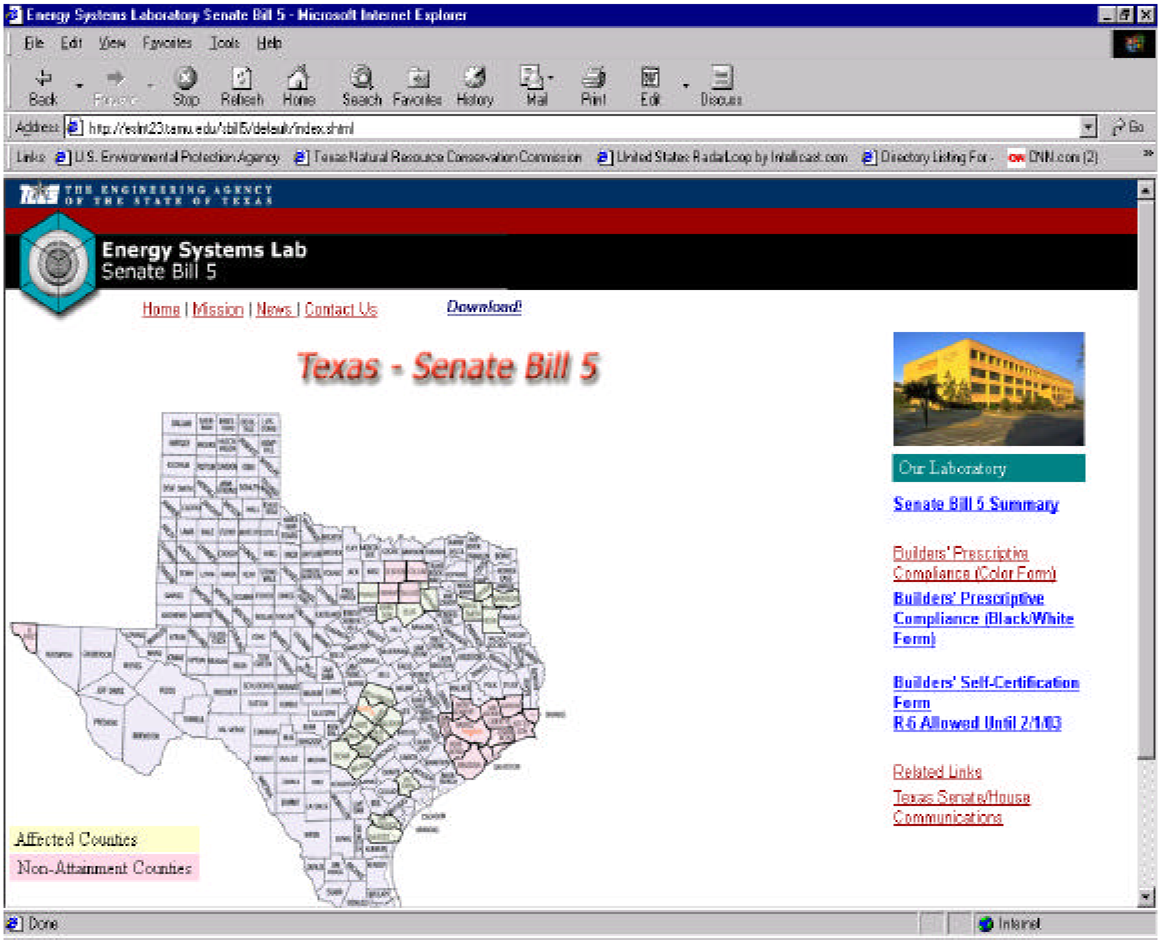


Figure 7: Laboratory's Senate Bill 5 web page for providing information about implementing the IECC/IRC.

# 4 RECOMMENDATIONS

The Energy Systems Laboratory recommends the following measures to improve the effectiveness of Senate Bill 5:

- Refinement of the analysis method for reporting emissions reductions.
- Identification of health issues associated with improved energy use.
- Development of "Showcase houses on wheels".
- Focus on hard-to-reach areas
- Study the impact of improving the efficiency of manufactured housing
- Study the impact of including appliance efficiency standards.
- Capture and document the energy savings in Texas LoanSTAR and Rebuild America programs currently in place.

## 4.1 Refinement of the analysis method for reporting emissions reductions.

As we go forward, improved emissions reporting methods will need to be developed that provide greater accuracy in estimating ozone reductions from electricity reductions in buildings. The Laboratory can determine the energy reductions in the municipalities and counties using a variety of methods. Ideally, we would like to have a "1-sheet" list of key code parameters on each building with its location. We will have the computer systems in place to then determine the location and quantify the energy reductions. Next, this hourly energy reduction profile needs to be tied to a particular power plant, which has specific operating conditions on NOx emissions. ERCOT data, grid models and dispatch models will be required for this. Finally, the reduction of hourly NOx output of the power plant needs to be put into an acceptable hourly atmospheric model (i.e., Ozone day or August-September 2000 Episode day) to determine the reduction in ozone. Although this description is overly-simplified, four groups must work closely together to accomplish this task. These are the Laboratory, TNRCC, ERCOT and the UT Atmospheric Sciences Group. This group can put a solid, defensible set of ozone reductions forward to the US EPA. The legislature could address how to allow these data to be acquired as truly needed. Deregulation of the electric utilities is also complicating the acquisition of needed data.

## 4.2 Refinement of the analysis method for reporting costs associated with building to code standards.

Additional work needs to be done in quantifying and demonstrating the cost associated with building to code standards. Cost will increase due to added insulation, higher efficiency windows, higher efficiency air-conditioners and other added items. Cost will decrease due to being able to down-size air-conditioners and furnaces and some other potential design changes like high efficiency ducts. Also, energy bills will decrease. "Back of the envelop" calculations show that the initial cost increase can be $1,000 to $2,000 or so, depending on what is done. A payback of under 3 to 5 years should be expected. Technologies are being developed to enable the first cost to be less than the old building methods, allow better comfort and improved energy efficiency. The Laboratory needs to participate in developing, demonstrating and training builders in these technologies and methods.

## 4.3 Identification of health issues associated with improved energy use.

Along side of the cost issue is health. Homeowners are concerned with increased occurrence of asthma in children and other health related afflictions related to a "tighter" building. A tighter building can be a healthier building, if it is designed and maintained correctly. Proper ventilation becomes more problematic in a tight house as well. The Laboratory is ideally situated to provide the education and training on how to make the code adoption a major plus on improving the health of indoor environments.

4.4 Development of "Showcase houses on wheels".

Construct two or three "showcase houses on wheels" to demonstrate energy efficiency building techniques. This activity would address builder reluctance to accepting the energy codes. These showcase houses would be brought to Home Shows, State Fairs and other high traffic opportunities to demonstrate the impact of high efficiency windows, air-conditioners and other equipment, duct sealing, building envelop sealing and other energy efficiency technologies. The audience would be builders, local officials and home-buyers. This would require increased funding of $200,000 to $300,000 to construct these units and $100,000 / year on-going.

4.5 Focus on hard-to-reach areas

Hard to reach areas are a particular challenge because most of these areas do not have an infrastructure in their local government to support technical initiatives. The Laboratory proposes to train graduate students for direct interface with local officials, builders and homeowners to assist in delivering the needed skills to enable implementation of the energy efficiency requirements of SB5. This effort would add $300,000 to $400,000 / year on-going.

4.6 Study the impact of improving the efficiency of manufactured housing

Study the impact of improving the energy efficiency in manufactured homes and determine where cost effective enhancements should be done. Manufactured homes are not subject to the IRC / IECC codes[6]. Due to the low first cost of this housing, manufactured housing is experiencing an increase in market share and will likely negatively impact energy efficiency measures being taken in site-built housing. The Laboratory would work with manufacturers to determine the optimal improvements to make this housing more efficient. We would be looking at standards (above the federally mandated ones), which improve the cost efficiency and indoor air quality of this housing without adding a cost burden. This effort would require approximately $200,000 / year for 3 years.

4.7 Study the impact of improved appliance efficiency standards.

The current version of the IECC/IRC does not include a direct provision for reducing the energy use of a residence by improving the appliance energy efficiency, including lighting efficiency use in residences. Although appliance energy efficiency is currently regulated by national standards, significant state-wide electricity savings could be generated and, credits registered for emissions credits if the proper procedures were in place doing this. Therefore, it is recommended that the impact of improving appliance energy efficiency beyond the national standards be studied to determine if this is a cost effective way to help reduce emissions in non-attainment and affected counties.

4.8 Capture and document the energy savings in Texas LoanSTAR and Rebuild America programs currently in place.

Currently, Texas has documented over $100 million in energy savings in hundreds of buildings around the State of Texas. However, Measurement and Verification (M&V) on most of these buildings has been discontinued. Several studies by the Laboratory have shown that 20 to 30%+ of the savings will erode over time if these buildings are not carefully monitored[7]. Therefore, restarting the monitoring in these buildings

[6] The energy efficiency of manufactured homes is currently regulated by U.S.H.U.D. Other requirements include NFPA 501 Standard for Mobile Homes.

[7] Additional information about this can be found in the papers: Kumar, S., Haberl, J., Claridge, D., Turner, D., O'Neal, D., Sharp, T., Sifuentes, T., Lopez, F., Taylor, D., "Measurement and Verification Reality Check: A Yawning Gap Between Theory and Practice", Proceedings of the 2002 ACEEE Summery Study, (August); and Claridge, D., Liu, M., Deng, S., Turner, D., Haberl, J., Abbas, M., Bruner, H., Veteto, B., Lee, S. 2001. "Cutting Energy and Cooling Use Almost in Half Without Capital Expenditure in a Previously

and recommissioning the HVAC systems will likely produce well over $10 million in real dollar savings per year to the state and also have verifiable emissions reductions.

# 5 TECHNOLOGY OF REPORTING & VERIFYING EMISSIONS REDUCTIONS FROM ENERGY USED IN BUILDINGS

Senate Bill 5 will allow the TNRCC to obtain emissions reduction credits for reductions in electricity use and electric demand that are attributable to the adoption of the International Energy Conservation Code (IECC 2000) in non-attainment and affected counties. In order for the TNRCC to accomplish this, county-wide reductions in electricity use will be calculated by the Laboratory and presented to the TNRCC in a suitable format for calculating emissions reductions. Ultimately, the format and procedures for calculating emission savings must be approved by the EPA[8].

In this report two types of calculation procedures are discussed in regards to the estimation of emissions reductions from buildings: data requirements for the calculation of annual NOx reductions, and data requirements for hourly ozone modeling.

## 5.1 Procedures for Calculating Electricity Reductions

### 5.1.1 Residential Buildings

The methodology to accomplish this for residential buildings is presented in Figure 9 - Figure 13. This methodology is composed of several procedures that will calculate and verify savings using several different sources of information. These procedures include:

1. The calculation of electricity savings and peak demand reductions from the implementation of the IECC 2001 (Figure 8) in new residences in non-attainment and affected counties as compared against 1999 housing characteristics (IECC 2001 residential emissions reductions) using calibrated simulation.
2. A cross-check of the calculated energy use[9] against the published average energy use found in the USDOE's Residential Energy Characteristics Survey (RECS 1999)
3. A cross-check of electricity savings using a utility bill analysis method.
4. A cross-check of construction data using on-site visits.

#### 5.1.1.1 Residential: New Construction

<u>Calculation of emissions reductions.</u> The primary procedure for calculating the emissions reductions from the adoption of the IECC 2001 in new residences is shown in Figure 9 and Figure 10. Figure 9 is a flowchart of the overall procedure, which includes the information obtained from Figure 10. For each county, 1999 and 2002 residential housing characteristics will be ascertained according to the procedures in Figure 10. Using simulation, these characteristics are entered into the DOE-2 simulation to calculate the annual energy use of two average-sized residences, one representing the house with the average 1999 characteristics, and one representing the appropriate characteristics from the 2001 IECC. The annual electricity use of the 2001 IECC simulation is then subtracted from the annual electricity use of the similarly-sized 1999 residence to obtain the annual electricity savings, and peak electric demand savings.

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Retrofit Building", Proceedings of the Summer Study of the European Council for an Energy Efficient Economy (ECEEE), June 11-16, 2001, Mandeliu, Cote D'Azur, France.

[8] Additional information can be found in the TNRCC document "Conceptual Model for Ozone Formulation in the Houston-Galveston Area: Appendix A to Technical Support Document – Conceptual Model for Ozone Formulation", June 5, 2002.

[9] This energy use reported by RECS represents the total energy use, which would include electricity use and natural gas use.

Natural gas savings associated with space heating and the heating of domestic hot water would be calculated for informative purposes. The electricity savings attributable to the 2001 IECC energy conservation options would then be converted to $NO_x$ reductions per house using the appropriate state-wide, utility grid conversion model. Electricity savings would then be scaled to represent the county-wide savings by multiplying the annual residential building permits for each county. Total annual $NO_x$ reductions associated with the implementation of the 2001 IECC would then be calculated simultaneously for all non-attainment and affected counties using a state-wide conversion model.

In Figure 10 the detailed flowchart is shown for calculating the 2002 annual energy use of new residential construction for houses with and without the energy conserving features contained in the IECC 2001, chapters 4 and 6. This is accomplished with two separate calculations: a) one path that represents the standard house defined in the 2001 IECC chapter 4 and 5, that uses average housing characteristics for houses built in 1999 (left side of figure); and b) a second path that represents the standard house defined by the 2001 IECC that includes the energy conserving features[10] defined in chapter 4, 5 and 6 (right side of figure).

<u>Calculating baseline energy use of new construction.</u> The procedure for calculating the 2002 baseline residential energy consumption (left side of Figure 10) begins with the definitions of the standard house found in Chapter 4 of the 2001 IECC. These definitions are used to create a standard input file for the DOE-2 simulation program (LBNL 2000). This standard input file is then adjusted to reflect the average 1999 construction characteristics for each county[11] for type A-1 (single family) and type A-2 (all others) housing. The annual electricity and natural gas consumption for the average house[12] is then simulated using the DOE-2 program and the appropriate weather data[13] for each location. The annual, countywide, baseline energy consumption for new houses built in 2002 with characteristics that reflect the 2001 IECC and 1999 published data is calculated by multiplying the annual simulated energy use for an average house times the projected A-1 and A-2 county-wide housing permits for 2002. The projected A-1 and A-2 housing permits for each county are projected using multiple linear regression that utilizes countywide population growth and housing permits as shown in Figure 10. This baseline represents the expected annual energy use of all new construction in each county had those houses been constructed with the 2001 IECC chapter 4 and 5 “standard house” and average 1999 characteristics.

<u>Calculating code-compliant energy use of new construction</u>. The procedure for calculating the code-compliant 2002 residential energy consumption (right side of Figure 10) also begins with the definitions of the standard house found in Chapter 4 and 5 of the 2001 IECC. This code-compliant input file reflects the average 1999 house size[14] for each county and IECC Chapter 5 or 6 construction characteristics[15] for type A-1 (single family) and type A-2 (all others) housing. The annual electricity and natural gas consumption for a code-compliant house is then simulated using the DOE-2 program and the appropriate weather data for each location. The annual, countywide, code-compliant energy consumption for new houses built in 2002 with code-compliant characteristics is calculated by multiplying the annual simulated energy use for a code-complaint house times the projected A-1 and A-2 housing permits for 2002. This code-compliant use represents the expected annual energy use of all new code-complaint construction in each county. The total electricity savings which can be attributed to the adoption of the IECC 2001 are then calculated by comparing the difference in annual energy use of the baseline housing versus the code-compliant housing as shown in Figure 9.

<u>Reconciliation of the total savings.</u>

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[10] The energy conserving features in the IECC 2001 are the same as those contained in chapter 11 of the 2000 IRC, as modified by the 2001 Supplement (IECC 2001).
[11] The average 1999 construction characteristics represent the published data from several sources, including NAHB (2002), F.W. Dodge (2002), RECS (1999) and LBNL (1995).
[12] The average house size for each county is determined from published RECS (1995) data.
[13] The appropriate weather data for each county is the nearest TMY2 weather file that most accurately represents the 2001 IECC climate zone as shown in Figure 2.
[14] Uses the same average house size for each county as determined from published RECS (1995) data.
[15] These characteristics include insulation levels, glazing type, etc., as defined in Chapter 6 of the 2001 IECC or Chapter 11 of the 2001 IRC.

Several procedures have been identified to reconcile the savings calculations, including:

a) a cross-check of the calculated energy use against the published average energy use found in the USDOE's Residential Energy Characteristics Survey (RECS 1999) as shown in Figure 11;
b) a cross-check of energy savings using a utility bill analysis method as shown in Figure 12; and
c) a cross-check of construction data using on-site visits as shown in Figure 13.

Cross-check of the calculated energy use against published data. The procedure to cross-check the calculated energy use of the baseline houses and code-compliant houses against the average energy use published by the RECS (1999) is shown in Figure 11. It is important to note that this procedure is proposed for informative purposes, since exact agreement between the housing characteristics in the IECC 2001 and RECS is not anticipated, since the RECS data reflects actual average occupant behavior, and the IECC reflects a controlled occupant behavior. The procedure multiplies the expected number of A-1 and A-2 housing units times the average annual energy use per household published in RECS to obtain the county-wide annual energy use for all newly constructed houses. This value is expected to be useful in judging whether or not any adjustments are needed in the 2001 IECC Chapter 4 and 5 construction characteristics.

Cross-check of energy savings using utility bill analysis. The energy savings attributable to the adoption of the 2001 IECC will reconciled with monthly utility billing data using the well-known Princeton Scorekeeping Method (PRISM) (Fels 1986; Fels et al. 1995) as shown in Figure 12. In general, the difference between average 1999 and 2002 utility bills should decrease by an amount that is similar to the calculated savings from 2001 IECC adoption for similar sized houses, with equal numbers of occupants, in similar neighborhoods. In Figure 12 the procedure for accomplishing this is set forth. The procedure has two parallel paths, one for the 1999 housing stock (left side of Figure 12) and one for the 2002 housing stock (right side of Figure 12).

For the housing cross-check with utility billing data, the procedure begins by selecting a 1999 house and a 2002 house that have similar characteristics to the construction characteristics that were used for the primary calculation shown in Figure 9 and Figure 10. For each house 12 months of utility billing data are obtained and analyzed with PRISM. The resultant, valid parameters from PRISM[16] are then normalized by conditioned area to obtain a weather-normalized, averaged energy use per square foot. After the appropriate number of houses have been analyzed that represent a statistically significant sample of houses constructed in 1999 for each county (or for 2002), the Normalized Annual Consumption (i.e., $NAC_{1999}$ expressed as kWh/yr-$ft^2$) is compared against the similar parameter for houses constructed in 2002 (i.e., $NAC_{2002}$ expressed as kWh/yr- $ft^2$) to obtain the average electricity savings per square foot of conditioned area. This difference is then multiplied by the number of houses constructed in 2002 and the average conditioned area of the houses constructed in 2002 to obtain the total annual electricity savings per county. This total, county-wide, annual electricity savings calculated by utility bill analysis can then be compared to the total, county-wide, annual electricity savings calculated by simulation (i.e., Figure 9 and Figure 10). For each county, savings from the difference in 1999 versus 2002 utility bills are expected to be similar to savings calculated by simulation for similar houses, with similar household characteristics[17].

Cross-check of construction data using on-site visits.

A reconciliation will also be carried out to cross-check selected parameters for both the 1999 and 2002 housing characteristics for each county as shown in Figure 13. For the 1999 housing stock, on-site surveys of a statistically significant sample will be used to cross-check the average building characteristics[18] used to simulate the average house in each county. Adjustments can then be made to the average 1999 characteristics should significant differences be found.

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[16] The primary parameter of interest from the PRISM analysis is the Normalized Annual Consumption (NAC). The goodness of fit indicators used to determine a valid PRISM run include the CV(NAC), and PRISM's adjusted R^2.
[17] If necessary, a similar procedure can be used to cross-check heating savings with either a 5 parameter change-point model using monthly electricity utility bills, or a PRISM model applied to monthly natural gas utility bills.
[18] As previously mentioned the 1999 average building characteristics represent the average characteristics published by NAHB, F.W. Dodge and LBNL.

As shown in the right side of Figure 13, a similar procedure will be carried out for houses constructed in 2002 to determine if the on-site housing characteristics meet, or exceed the 2001 IECC. However, differences found in the 2002 characteristics will be noted as to whether or not these differences represent characteristics that are less stringent or more stringent than code. Characteristics that are less stringent that code will be communicated with code officials to determine how procedures to the code need to be modified to better meet code requirements. Characteristics that are more stringent than code will be credited to the countywide energy savings as above code savings.

#### 5.1.1.2 Residential: Existing Construction

Existing residential buildings that undergo a significant remodeling are addressed by the 2000 IECC/IRC. To account for the energy savings from these activities, procedures would be similar to those for new construction that track remodeling permits, including how the buildings are complying with the 2000 IECC/IRC. Different procedures may need to be developed for tracking existing building 2000 IECC/IRC activities. For example, it may be more efficient to track the activity by the type of retrofit, including: envelope, HVAC system, etc. Once a tracking procedure has been developed, then a suitable accounting scheme can be developed and implemented to include these savings in with the savings from new construction activities.

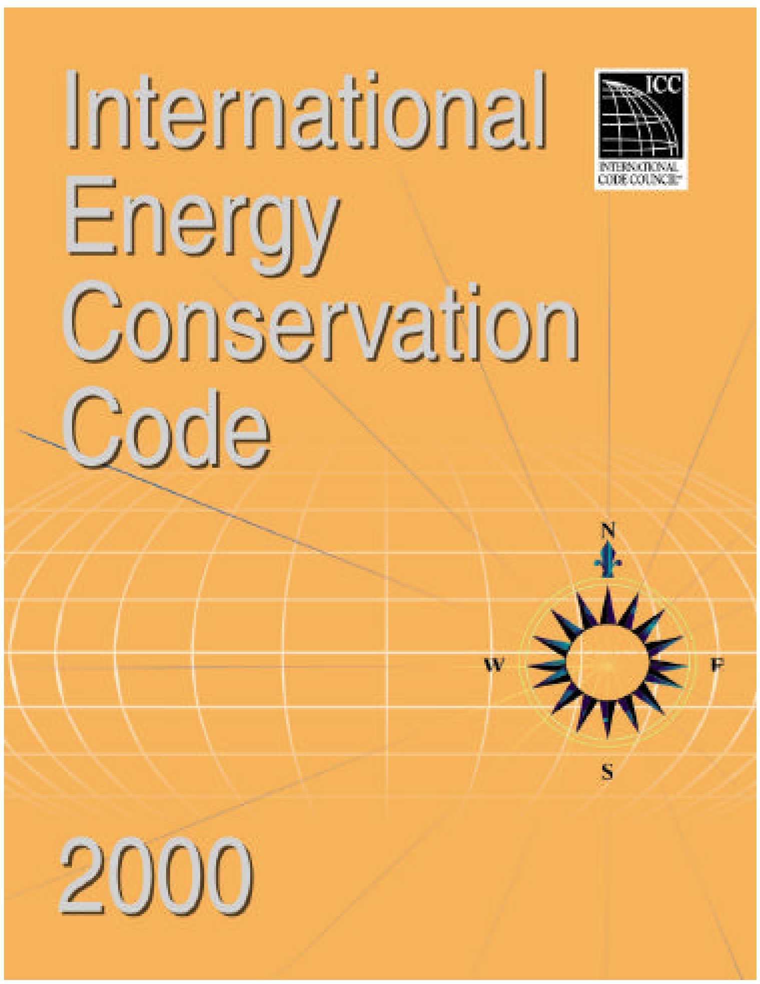


Figure 8: 2000 International Energy Conservation Code (IECC).

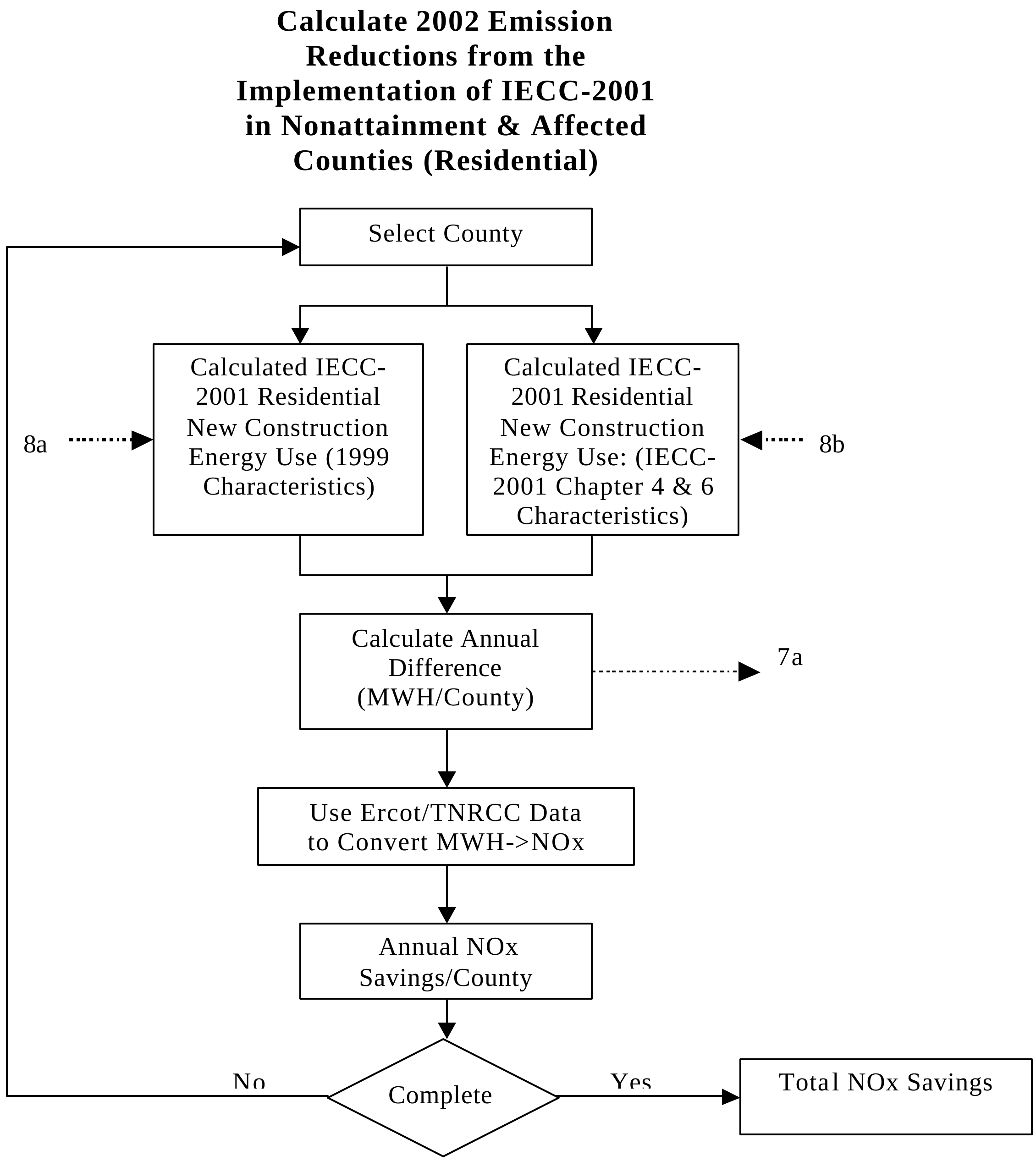


Figure 9: Overall flowchart for calculation of emission reductions from implementation of IECC/IRC 2001 in residential construction in non-attainment and affected counties.

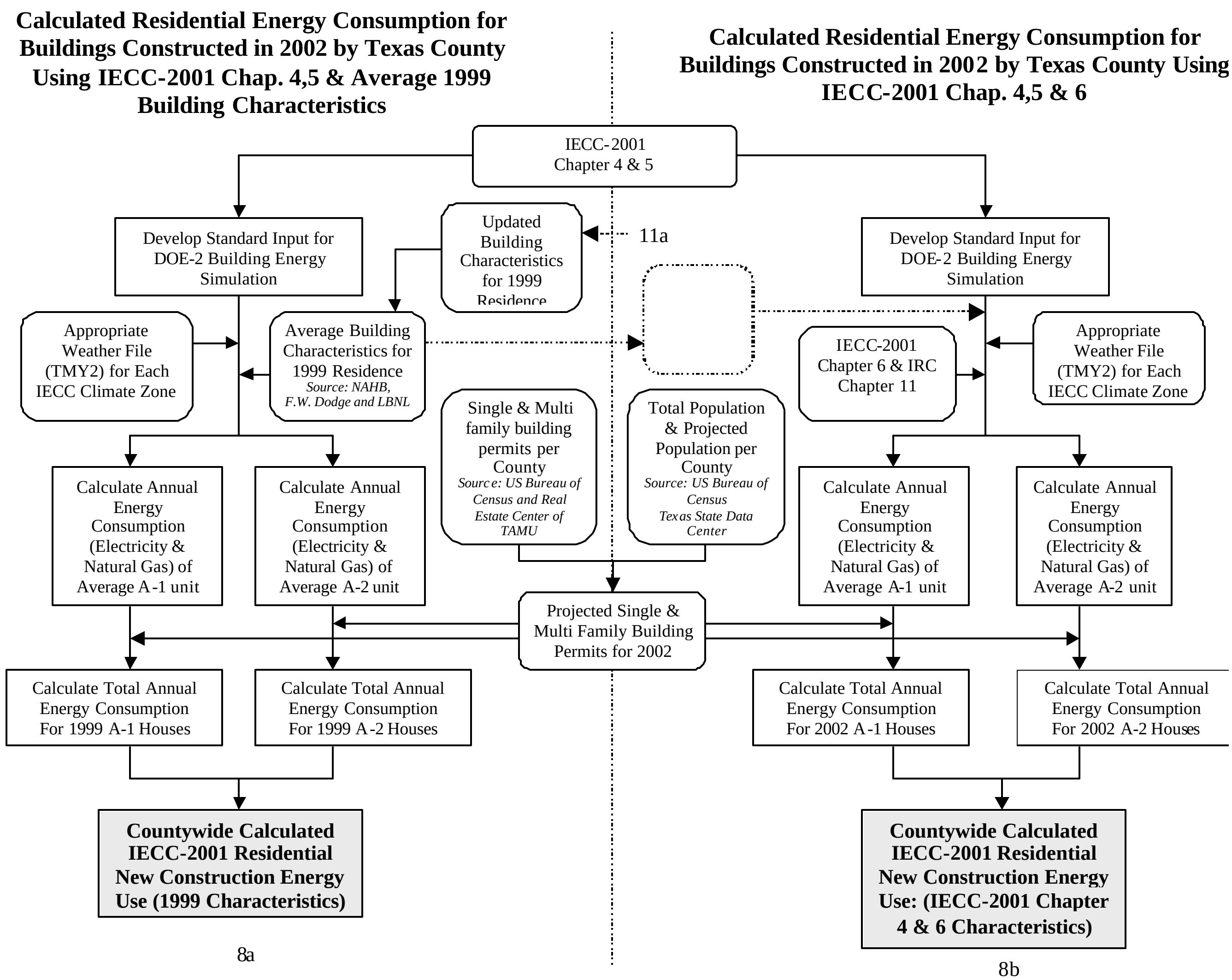


Figure 10: Calculation of countywide residential new construction energy consumption (1999 characteristics and 2001 IECC/IRC).

# Estimated Residential Energy Consumption for Buildings Constructed in 1999 by Texas County

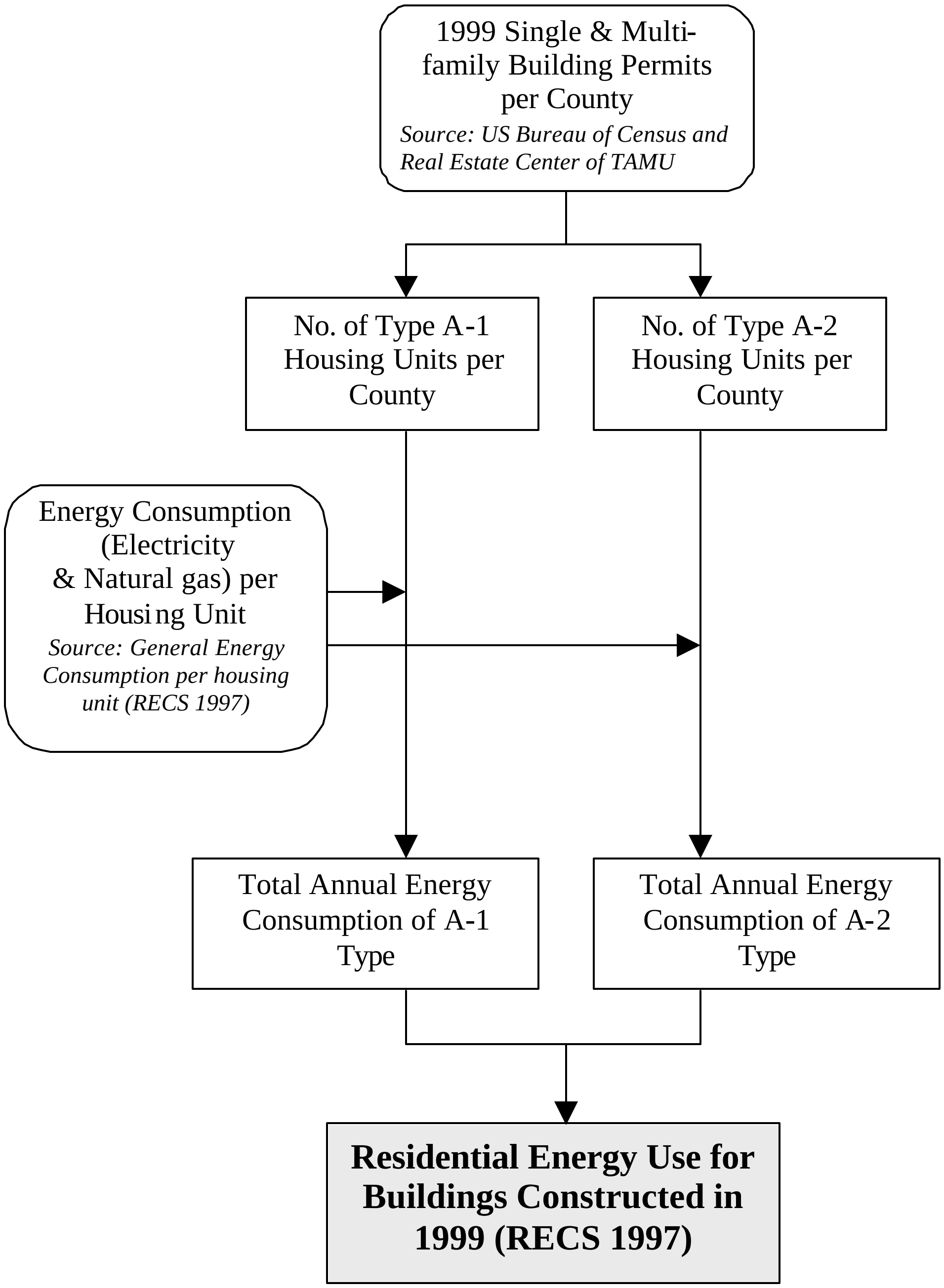


Figure 11: Estimated residential energy consumption for buildings constructed in 1999 by Texas county.

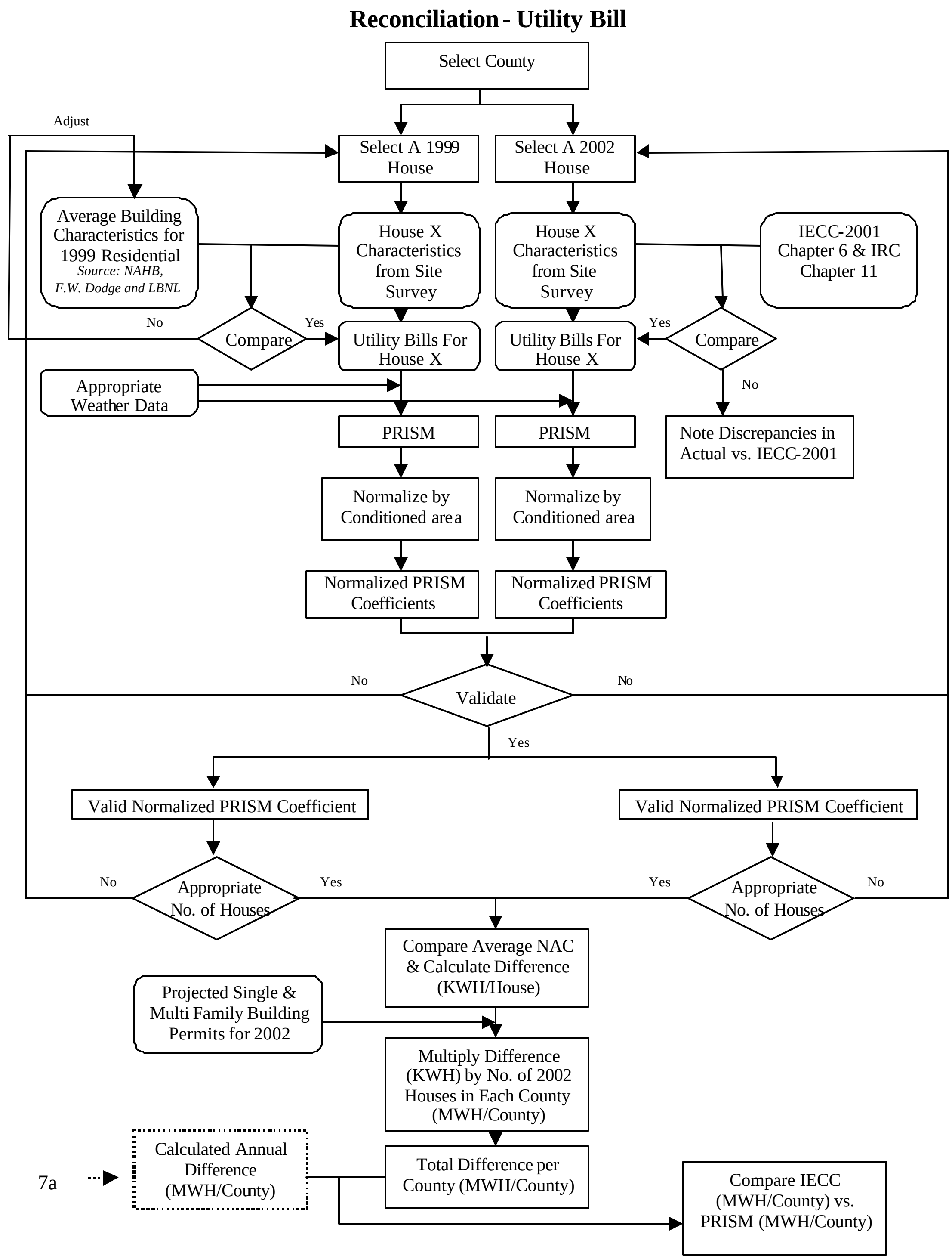


Figure 12: Reconciliation of residential energy savings using utility bill analysis.

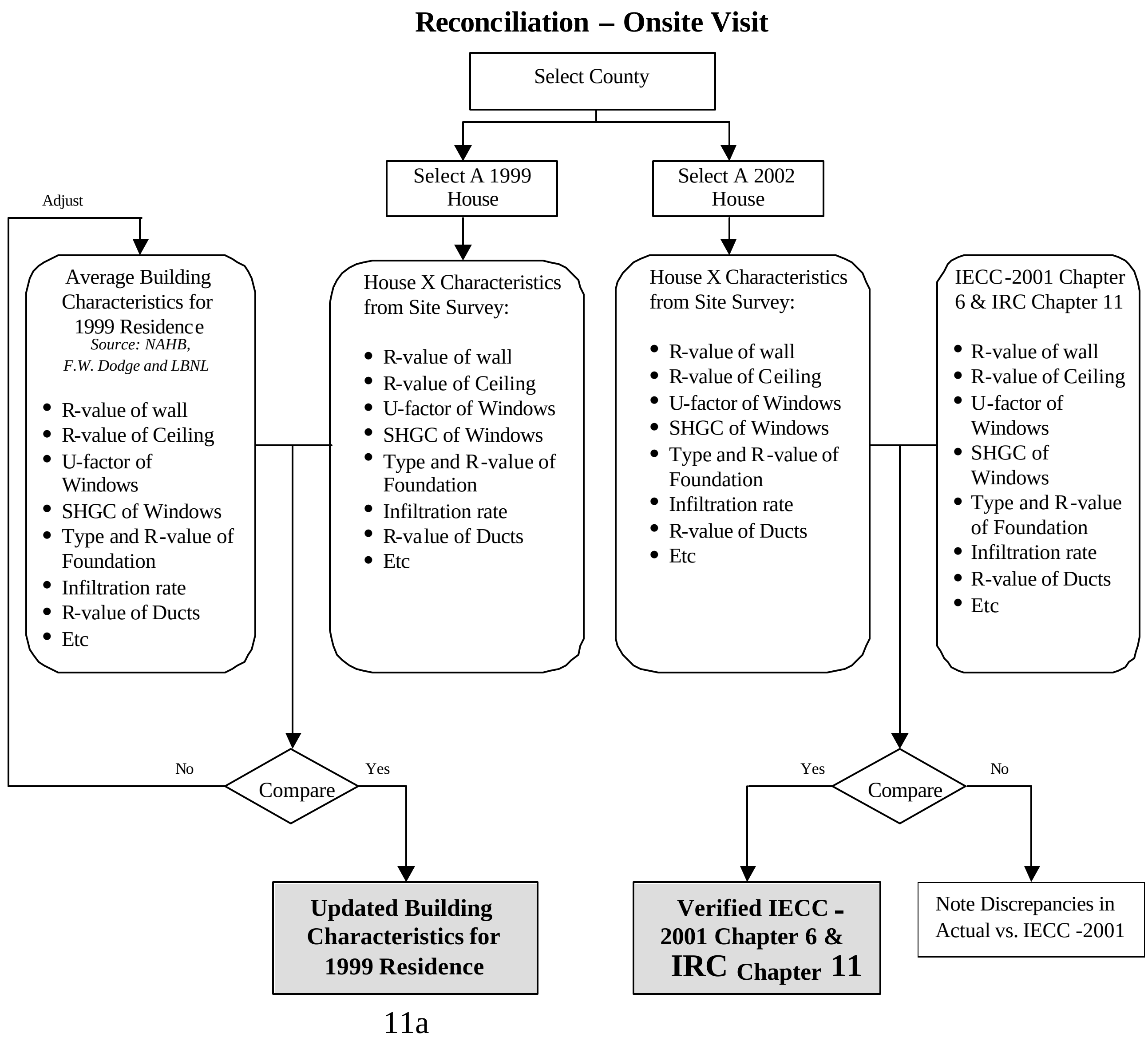


Figure 13: Reconciliation residential housing characteristics using on-site surveys.

### 5.1.2 Commercial/Industrial Buildings

The methodology to accomplish this for commercial buildings is presented in Figure 14 through Figure 18. These procedures incorporate and verify savings using several different sources of information. These procedures include a flowchart of the overall procedure, which includes the information obtained from Figure 15. For each county, 1999 and 2002 commercial building characteristics will be ascertained according to the procedures in Figure 15. Using simulation, these characteristics are entered into the DOE-2 simulation to calculate the annual energy use of two representative buildings, one representing the commercial building with the average 1999 characteristics, and one representing the appropriate characteristics from the 2001 IECC. The annual electricity use of the 2001 IECC simulation is then subtracted from the annual electricity use of the similarly-sized 1999 building to obtain the annual electricity savings, and peak electric demand savings. Natural gas savings associated with space heating and the heating of domestic hot water would be calculated for informative purposes. The electricity savings attributable to the 2001 IECC energy conservation options would then be converted to $NO_x$ reductions per building using the appropriate state-wide, utility grid conversion model. Electricity savings would then be scaled to represent the county-wide savings by multiplying the annual commercial building permits for each county. Total $NO_x$ reductions associated with the implementation of the 2001 IECC would then be calculated simultaneously for all non-attainment and affected counties using a state-wide conversion model.

In Figure 15 the detailed flowchart is shown for calculating the 2002 annual energy use of new commercial building construction with and without the energy conserving features contained in the IECC 2001, chapters 4, and 8. This is accomplished with two separate calculations: a) one path that represents the standard building defined in the 2001 IECC chapter 4 and 8, that uses average characteristics for buildings built in 1999 (left side of figure); and b) a second path that represents the standard building defined by the 2001 IECC that includes the energy conserving features[19] defined in chapter 7 and 8 (right side of figure).

Calculating baseline energy use of new construction. The procedure for calculating the 2002 baseline commercial building energy consumption (left side of Figure 15) begins with the definitions of the standard building found in Chapters 4 and 8 of the 2001 IECC. These definitions are used to create a standard input file for the DOE-2 simulation program (LBNL 2000). This standard input file is then adjusted to reflect the average 1999 construction characteristics for each county[20] for office, retail and industrial buildings. The annual electricity and natural gas consumption for each building type[21] is then simulated using the DOE-2 program and the appropriate weather data[22] for each location. The annual, countywide, baseline energy consumption for new buildings built in 2002 with characteristics that reflect the 2001 IECC and 1999 published data is calculated by multiplying the annual simulated energy use for an average building times the projected county-wide construction permits for 2002. The projected office, retail and industrial construction permits for each county are projected using regression that utilizes countywide population growth and construction permits. This baseline represents the expected annual energy use of all new construction in each county had those buildings been constructed with the 2001 IECC chapter 4 and 8 “standard building” and average 1999 characteristics.

Calculating code-compliant energy use of new construction. The procedure for calculating the code-compliant 2002 commercial building energy consumption (right side of Figure 15) also begins with the definitions of the standard building found in Chapter 4 and 8 of the 2001 IECC. This code-compliant input file reflects the 1999 floor area[23] for office, retail, industrial permits in each county and IECC Chapter 7 or

[19] The energy conserving features in the IECC 2001 are those contained in chapter 8 of the 2000 IRC, as modified by the 2001 Supplement (IECC 2001).
[20] The average 1999 construction characteristics represent the published data from several sources, including F.W. Dodge (2002), CBECS (1995) and LBNL (1995).
[21] The average building size for each county is determined from published CBEC (1995) data.
[22] The appropriate weather data for each county is the nearest TMY2 weather file that most accurately represents the 2001 IECC climate zone as shown in Figure 2.
[23] This is derived from the published county-wide construction permit data on file with the Real Estate Center at Texas A&M University, also cross-checked with CBECS (1995) data.

8 construction characteristics[24]. The annual electricity and natural gas consumption for a code-compliant building is then simulated using the DOE-2 program and the appropriate weather data for each location. The annual, county-wide, code-compliant energy consumption for new buildings built in 2002 with code-compliant characteristics is calculated by multiplying the annual simulated energy use for a code-complaint buildings times the projected building permits for 2002. This code-compliant use represents the expected annual energy use of all new code-complaint construction in each county. The total electricity savings that can be attributed to the adoption of the IECC 2001 are then calculated by comparing the difference in annual energy use of the baseline building versus the code-compliant building as shown in

Reconciliation of the total savings.

Several procedures have been identified to reconcile the savings calculations, including:

1. a cross-check of the calculated energy use against the published average energy use found in the USDOE's Commercial Building Energy Characteristics Survey (CBECS 1995),
2. a cross-check of energy savings using a utility bill analysis method, and
3. a cross-check of construction data using on-site visits.

Cross-check of the calculated energy use against published data. The procedure to cross-check the calculated energy use of the baseline building and code-compliant building against the average energy use published by the CBECS (1995) as shown in Figure 16. It is important to note that this procedure is proposed for informative purposes, since exact agreement between the office, retail and industrial characteristics in the IECC 2001 and CBECS is not anticipated, since the CBECS data reflects actual average occupant behavior, and the IECC reflects a controlled occupant behavior. The procedure multiplies the expected number of office, retail and industrial building area times the average annual energy use per unit area published in CBECS to obtain the county-wide annual energy use for all newly constructed buildings. This value is expected to be useful in judging whether or not any adjustments are needed in the 2001 IECC Chapter 4, 7 and 8 construction characteristics.

Cross-check of energy savings using utility bill analysis. The energy savings attributable to the adoption of the 2001 IECC will also be reconciled with monthly utility billing data using ASHRAE's Inverse Model Toolkit algorithms (IMT) (Kissock et al. 2001) is shown in Figure 17 in 2002 utility bills should decrease by an amount that is similar to the calculated savings from 2001 IECC adoption for similar sized office, retail or industrial facility with similar characteristics and functional use. In has two parallel paths, one for the 1999 building stock and one for the 2002 building stock.

For the building cross-check with utility billing data, the procedure begins by selecting a 1999 building and a 2002 building that have similar characteristics to the construction characteristics that were used for the primary calculation. For each building 12 months of utility billing data are obtained and analyzed with the ASHRAE IMT. The resultant, valid parameters from IMT[25] are then normalized by conditioned area to obtain a weather-normalized, averaged energy use per square foot. After the appropriate number of buildings have been analyzed that represent a statistically significant sample of buildings constructed in 1999 for each county (or for 2002), the normalized annual consumption (i.e., expressed as kWh/yr-ft$^2$) is compared against the similar parameter for buildings constructed in 2002 (i.e., also expressed as kWh/yr-ft$^2$) to obtain the average electricity savings per square foot of conditioned area. This difference is then multiplied by the square footage reported in the building permits constructed in 2002 and the average conditioned area of the buildings constructed in 2002 to obtain the total annual electricity savings per county. This total, county-wide, annual electricity savings calculated by utility bill analysis can then be compared to the total, county-wide, annual electricity savings calculated by simulation. For each county, savings from the difference in 1999 versus 2002 utility bills are expected to be similar to savings calculated by simulation for similar buildings, with similar characteristics.

[24] These characteristics include insulation levels, glazing type, etc., as defined in Chapter 8 of the 2001 IECC or Chapter 7 of the 2000 IECC, which references ASHRAE Standard 90.1 1999 (w/o amendments).

[25] The primary parameter of interest from the ASHRAE IMT depends upon the model selection, which includes: a one parameter mean model, a two parameter model, three, four and five parameter change-point models, variable based degree models, and combined models that utilize multiple linear regression with 1,2,3,45 or VBDD models. The goodness of fit indicators used to determine a valid IMT run include the CV(RMSE), RMSE, and IMT's adjusted R^2.

Cross-check of construction data using on-site visits.

A reconciliation will also be carried out to cross-check selected parameters for both the 1999 and 2002 building characteristics for each county as shown in Figure 18. For the 1999 building stock, on-site surveys of a statistically significant sample will be used to cross-check the average building characteristics[26] used to simulate the average building in each county. Adjustments can then be made to the average 1999 characteristics should significant differences be found.

As shown in the right side of the figure adjustments will be carried out for buildings constructed in 2002 to determine if the on-site building characteristics meet, or exceed the 2001 IECC. However, differences found in the 2002 characteristics will be noted as to whether or not these differences represent characteristics that are less stringent or more stringent than code. Characteristics that are less stringent that code will be communicated with code officials to determine how procedures to the code need to be modified to better meet code requirements. Characteristics that are more stringent than code will be credited to the countywide energy savings as above code savings.

5.1.2.1 Commercial/Industrial Buildings: Existing Construction

Existing commercial buildings undergo a significant remodeling are addressed by the 2000 IECC/IRC. To account for the energy savings from these activities, procedures similar to those shown for new construction will be applied to track remodeling permits, including how the buildings are complying with the 2000 IECC/IRC. Different procedures may need to be developed for tracking existing building 2000 IECC/IRC activities. For example, it may be more efficient to track the activity by the type of retrofit, including: envelope, HVAC system, etc. Once a tracking procedure has been developed, then a suitable accounting scheme can be developed and implemented to roll these savings into the savings from new construction activities.

5.1.3 Renewables Applied to Buildings

The application of renewable energy systems in buildings are addressed by the 2000 IECC/IRC. To account for the energy savings from these activities, the procedures shown in Figure 19 and Figure 20 will be used to track the installation of projects that utilize renewables, according to the procedures in the 2000 IECC/IRC. In each county the number and type of renewable energy system will be evaluated to determine the displaced electricity use. Characteristics about each system will need to be collected, including: the type of system, $ft^2$ of aperature, orientation, tilt, systems characteristics, etc. These characteristics will then be input into either the FCHART or PVFCHART[27], depending upon system type, and the annual energy use simulated with the appropriate program. Total county-wide energy use is the cumulative total energy production of all systems installed in a county.

5.1.4 Calculation of Total Annual County-wide IECC/IRC Electricity Reductions.

Total annual, county-wide IECC/IRC electricity reductions would be the total of the savings from IECC/IRC application to residential, commercial/industrial, and renewable energy applications. Total savings from non-attainment and affected counties would incorporate savings from the county-wide IECC/IRC reductions. Total state-wide savings would be calculated in a similar fashion using county-wide savings from all Texas counties. The county-wide and state-wide models would also be used to generate either annual kWh totals, peak kW values, or 24-hour profiles, which would be needed for the hourly

[26] As previously mentioned the 1999 average building characteristics represent the average characteristics published by F.W. Dodge, CBECS and LBNL.
[27] FCHART and PVFCHART are nationally recognized solar analysis software developed by S.A. Klein, and W. A. Beckman at the, Solar Energy Laboratory, Mechanical Engineering Laboratory, 1500 Engineering Drive, University of Wisconsin – Madison, WI 53706.

photochemical modeling of ozone in non-attainment and affected counties for EPA ozone day or Episode day calculations as defined in the next section.

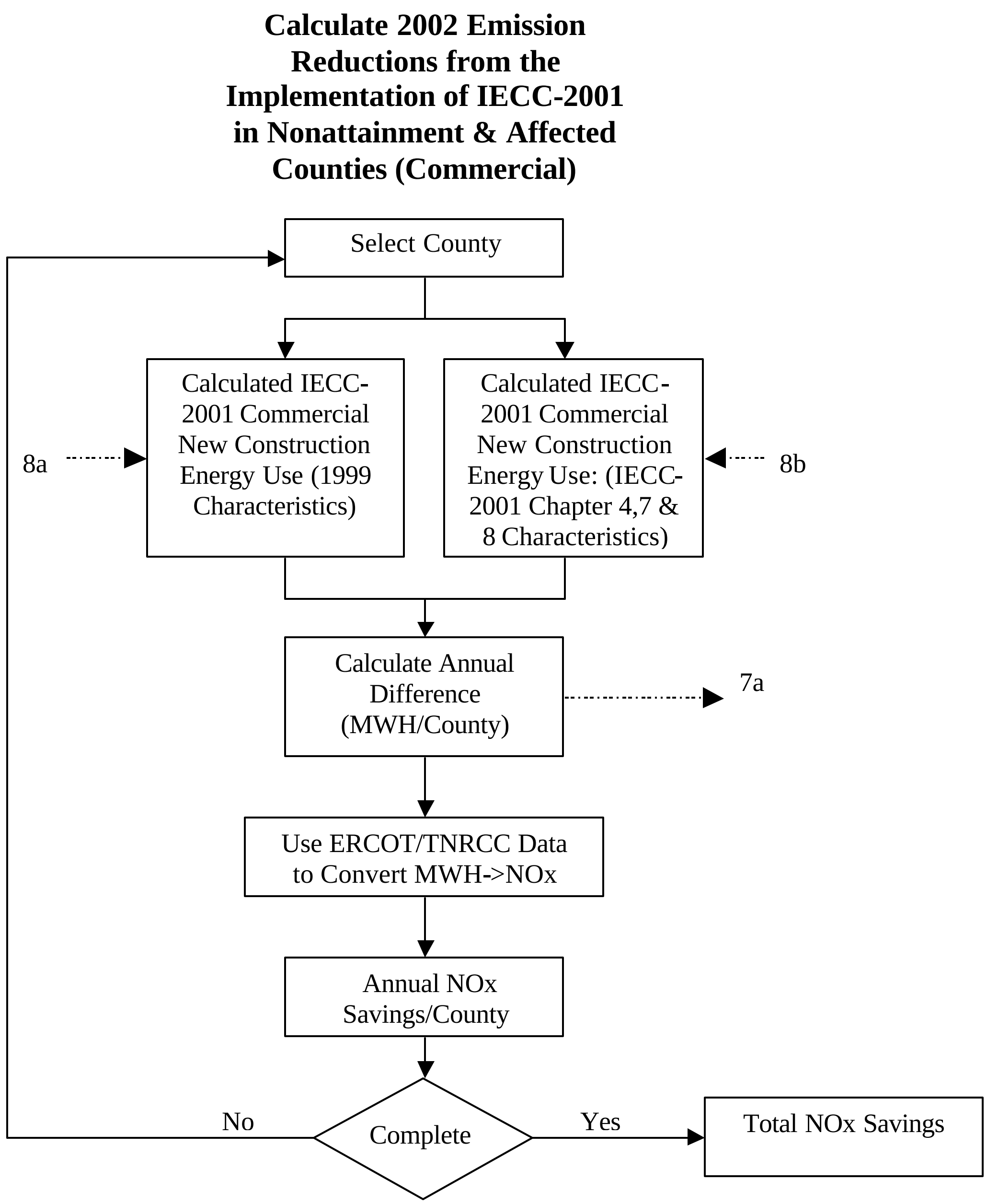


Figure 14: General flowchart for calculation of emission reductions from implementation of IECC/IRC 2001 in commercial buildings in non-attainment and affected counties.

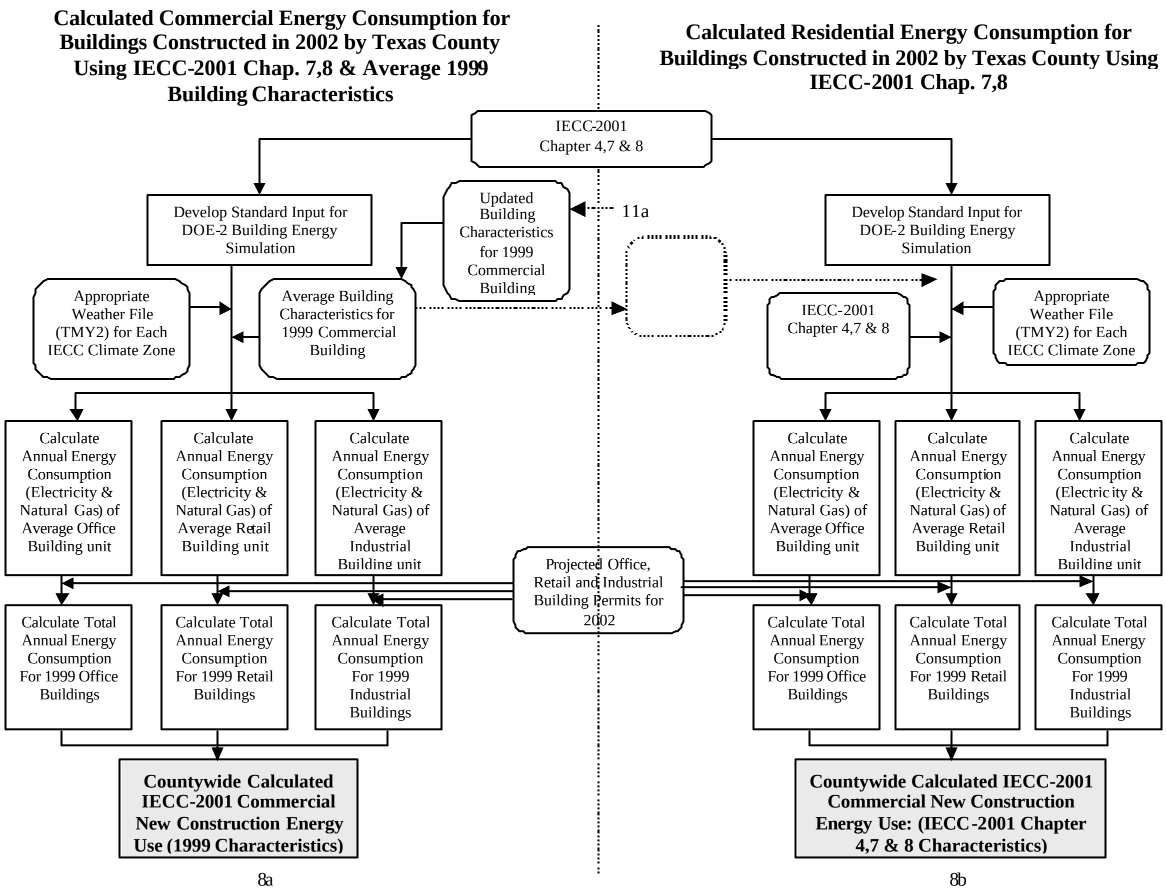


Figure 15: Calculation of countywide commercial new construction energy consumption (1999 characteristics and 2001 IECC/IRC).

## Estimated Commercial Energy Consumption for Buildings Constructed in 1999 by Texas County

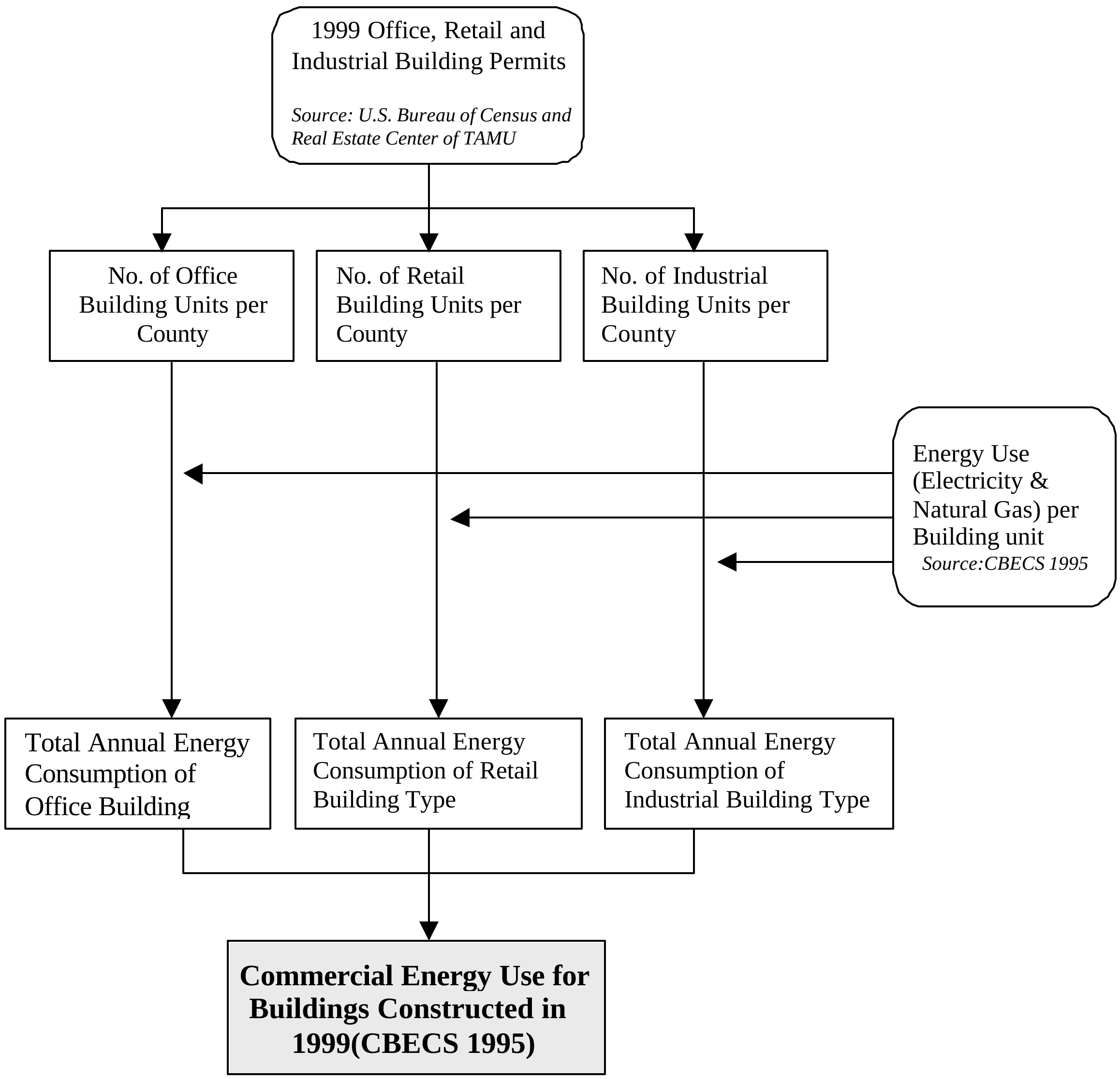


Figure 16: Estimated commercial energy consumption for buildings constructed in 1999 by Texas county.

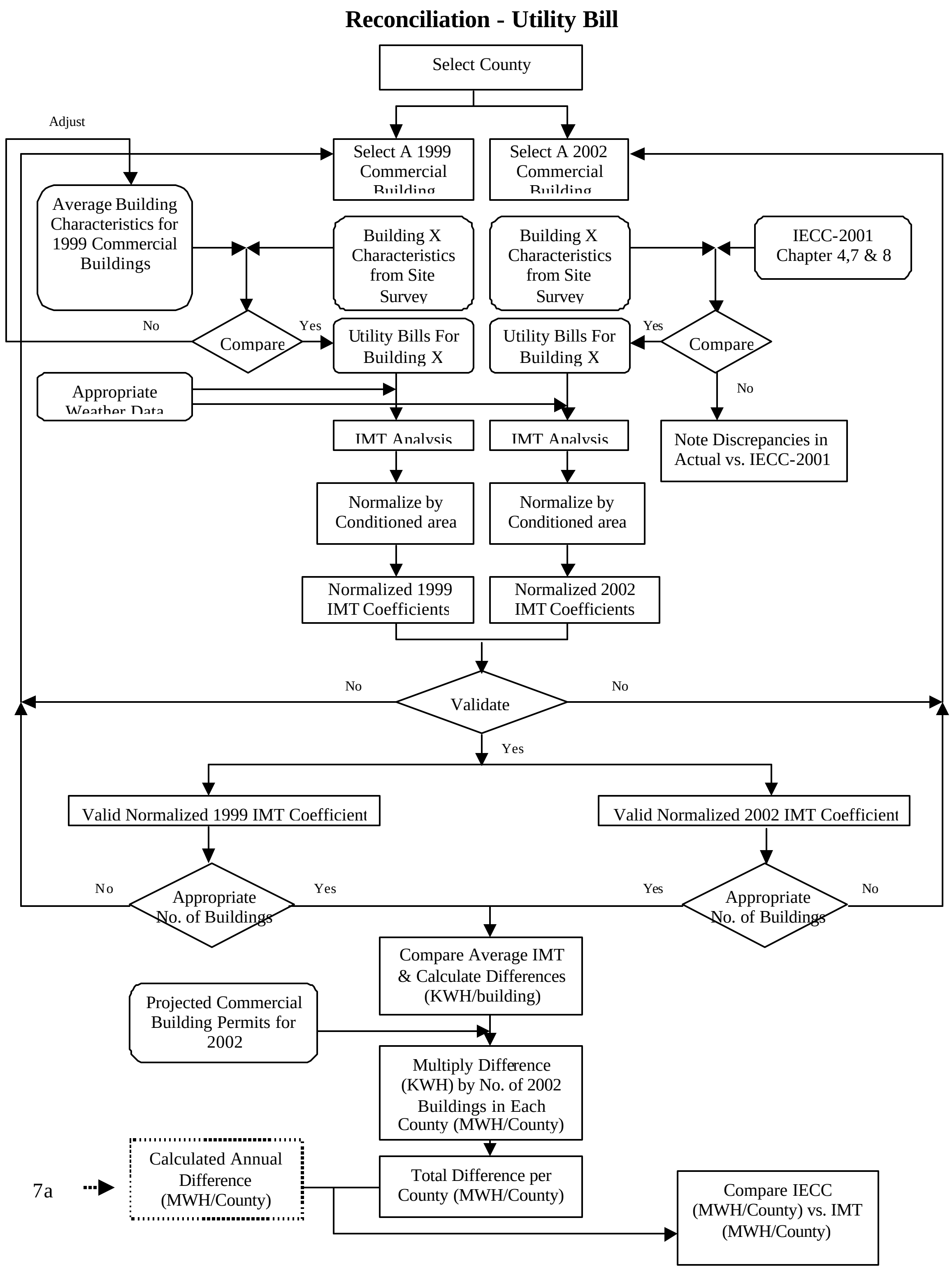


Figure 17: Reconciliation of commercial building energy savings using utility bill analysis.

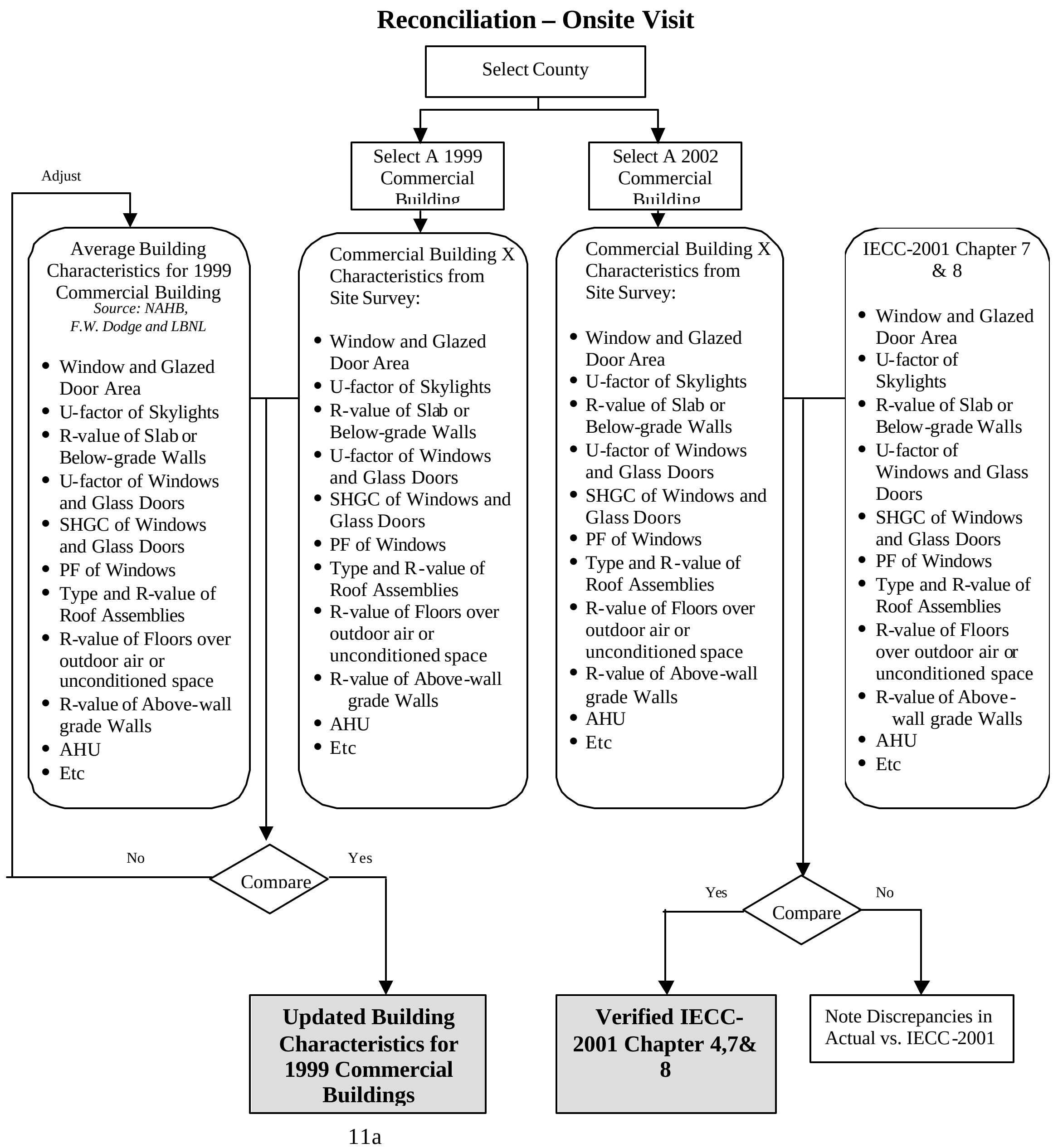


Figure 18: Reconciliation commercial building characteristics using on-site surveys.

**Calculate Emission Reductions from**

**Renewable Energy Production by Texas County**

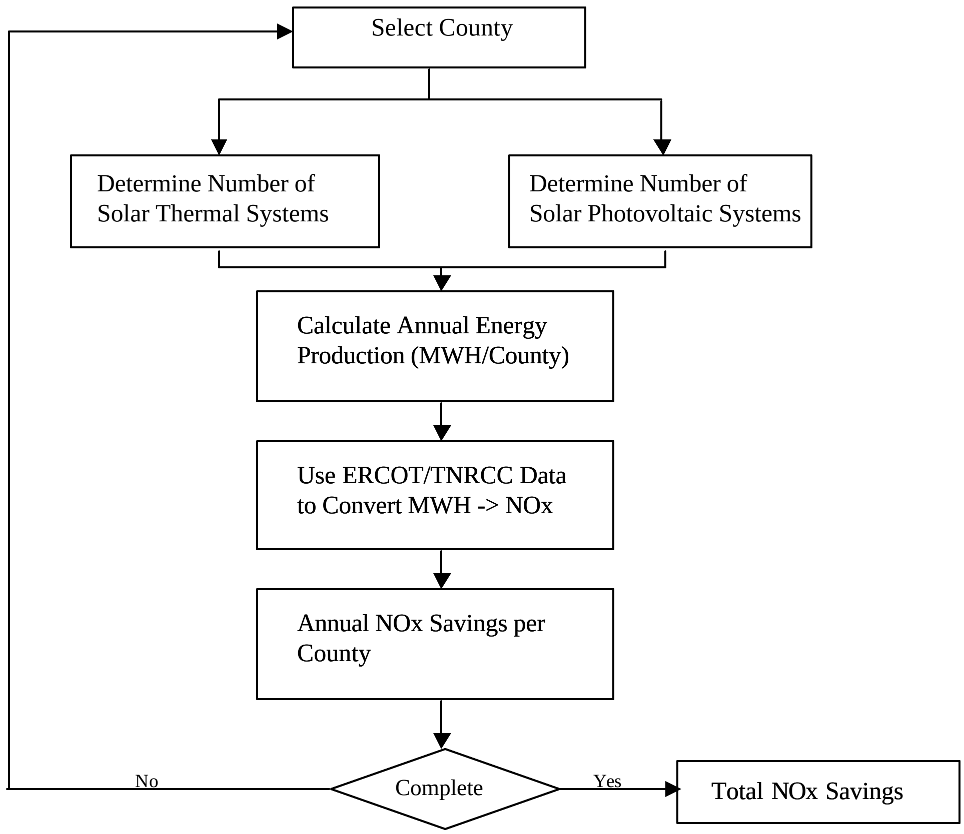


Figure 19: General flowchart for calculation of emission reductions from the use of renewables as incorporated in the IECC/IRC 2001 in residential or commercial/industrial buildings in non-attainment and affected counties.

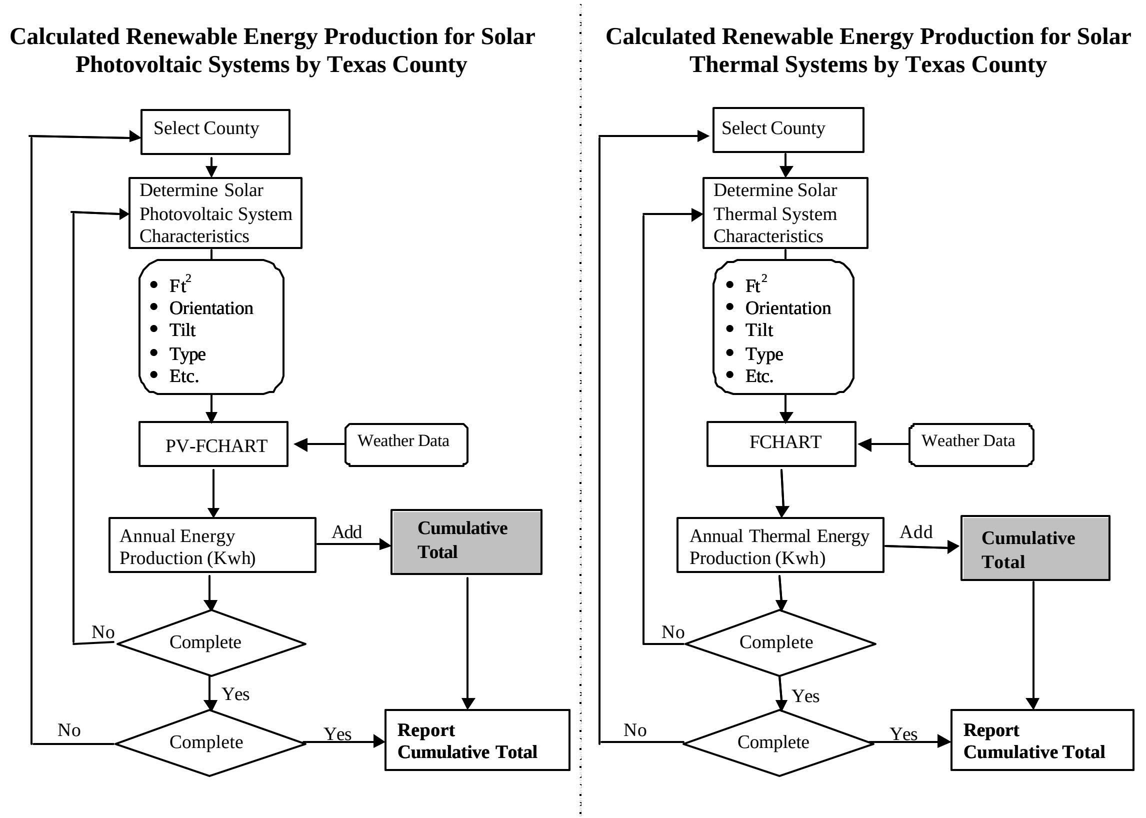


Figure 20: Detailed calculation of county-wide solar thermal or photovoltaic energy generation in residential or commercial/industrial new construction.

## 5.2 Procedures for Calculating Annual NOx Reductions.

The annual NOx estimation procedure proposed by the TNRCC requires annual, county-wide kWh reductions and peak kW reductions[28]. This methodology estimates the NOx emission reductions resulting from the energy savings in building. The input for the methodology is the expected annual electricity savings (MWh) for 2007 for each service territory. The output of the methodology is county-wide annual NOx emission reductions from electricity generators, which are converted into daily values by dividing the annual value by 365 days.

The proposed TNRCC annual NOx calculation methodology involves the following steps as shown in Figure 21:

Step 1. Estimate the amount of electricity generation that would be curtailed in each service territory for a given amount of electricity demand savings in a particular service territory. This step would involve the calculation of county-wide electricity savings from implementation of the IECC/IRC. The calculation begins with the county-wide simulations of standard versus IECC/IRC-compliant residential, commercial and industrial buildings. These simulations use the same input files that were used to calculate the annual electricity savings (kWh) and demand savings (kW).

Step 2. Estimate the amount of generation from each plant that would be curtailed for a given amount of generation curtailment in a particular service territory. This step would be performed using the EPA's E-GRID[29] database, which contains information about how much electricity was exchanged between each power control area within the ERCOT region in 1998. This information is used to determine which power plant supplied the electricity.

Step 3. Combine information from the first two steps together to estimate the electricity generation reductions from each plant in the ERCOT region for a given amount of electricity demand reduction occurring in a particular service territory. This step uses the E-GRID database to estimate the location of the electricity generation reductions to the plant level within a particular power control area using E-GRID plant-level data, and includes removal of electricity generating units expected to retire by 2007, as well as the addition of new units. Units are assigned to the power production using E-GRID's plant fuel type and capacity model, which are specific to each plant.

Step 4. Apply plant specific emission factors to the curtailed generation at each plant, which are the results from step 3.In this step information from the previous steps is combined so that the generation reductions for each plant within ERCOT is determined for a given amount of electricity demand savings expected for a particular service territory.

Step 5. Cumulate the annual emission reductions at each location into county-wide totals. In this step E-GRID assigns NOx emissions factors to the generation reduction to determine the emission reductions.

Step 6. Cumulate plant-level data into county-wide data. In this step plant-level data are summarized by county to produce county-wide NOx reductions attributable to implementation of the IECC/IRC.

[28] For additional details regarding this procedure see: Draft Houston/Galveston Attainment Demonstration and Post-1999 Rate-of-Progress SIP: Appendix A – Description of the Methodology for Determining Credit for Energy Efficiency, Texas Natural Resources Conservation Commission, Austin, Texas, June 5th, 2002 proposal.
[29] E-GRID, Ver. 2, is the EPA's Emissions and Generation Resource Integrated Database (Version 2). This publicly available database can be found at www.epa.gov/airmarkets/egrid/.

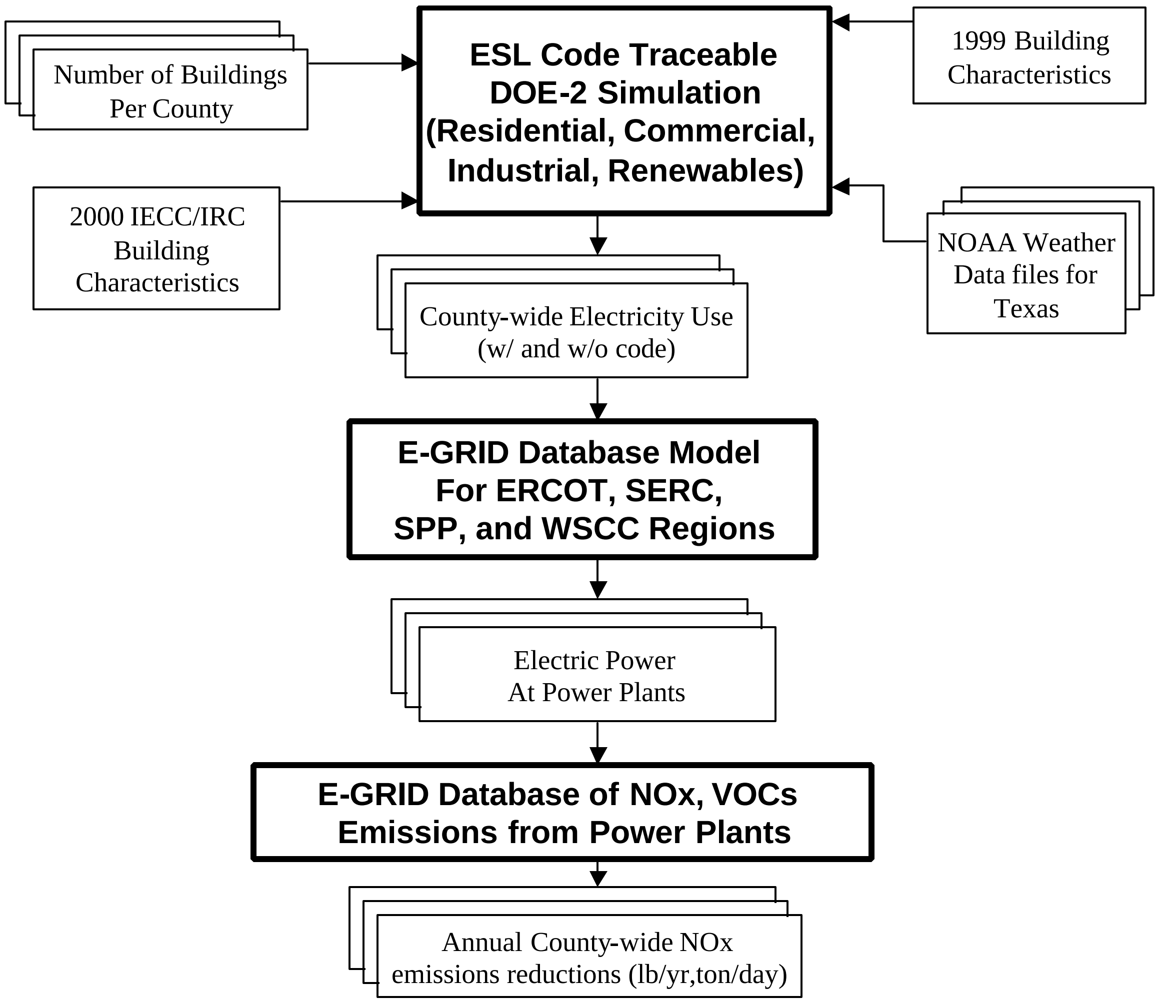


Figure 21: Annual NOx reporting procedure proposed by TNRCC (Source: TNRCC 2002)

## 5.3 Procedures for Modeling Hourly Ozone Reductions.

The proposed procedures for modeling hourly ozone reductions are shown in Figure 22. This procedure requires data and calculations from several state agencies, university labs and private entities[30]. As indicated in the upper portion of Figure 22, the procedure begins with the simulated, hourly, county-wide electricity savings from the implementation of the IECC/IRC to residential, commercial and industrial facilities, followed by the calculation of the electrical power production at the power plant using the appropriate grid model. The hourly, plant-specific power generation is then linked to hourly, TNRCC-measured pollutants for each plant to obtain the hourly, NOx, VOC and other pollutants associated with the power production at the time of the simulation. These hourly NOx and VOC are then merged together with other sources of NOx and VOC and fed into the hourly photochemical model along with the prevailing weather conditions to allow for the calculation of the ozone pollution. The following sections describe each of these procedural tasks in more detail.

### 5.3.1 Calculation of Hourly County-wide IECC/IRC Electricity Profiles.

The calculation of the ozone emissions reductions begins with the county-wide simulations of standard versus IECC/IRC-compliant residential, commercial and industrial buildings. These simulations use the same input files that were used to calculate the annual electricity savings (kWh) and demand savings (kW), which are re-simulated using the EPA Ozone-day weather conditions and the August-September 2000 Ozone Episode day weather conditions[31]. An example of the 24-hour profile from one of these simulations is shown in Figure 23. County-wide, 24-hour electricity demand profiles are then assembled from simulations of diversified profiles[32].

### 5.3.2 Calculation of Stationary Electricity Reductions From County-wide Electricity Reductions

Files containing the hourly, county-wide simulated electricity profiles are then input to the appropriate electricity grid models[33]. The electric grid models then assign the power production to specific power plants, after calculating the transmission and distribution losses. Figure 24 shows the electric power grid for ERCOT[34], which connects the different investor-owned utilities and municipal utilities as shown in Figure 25 shows the different Retail Electric Service regions. Specific dispatch models of power generation equipment would then selected to represent varying pollution production scenarios. These scenarios also include existing power generation plants and new power generation plants as shown in Figure 26 to allow for the evaluation of the variation in new low-NOx technologies that are expected to be introduced in the near future.

### 5.3.3 Calculation of NOx Reductions From Stationary Electricity Reductions

These power generation scenarios for the Ozone day and August-September 2000 Episode day periods are then matched with the TNRCC-measured NOx, VOC and other pollutants associated with the specific power generation equipment at each power plant[35] to allow for the calculation of NOx and VOCs point sources associated with the Ozone day and Episode periods.

[30] These entities ultimately would include: the Energy Systems Laboratory (ESL), the Public Utilities Commission (PUC), the State Energy Conservation Office (SECO) for the calculation of county-wide, hourly electricity profile changes, ERCOT, SERC, SPP and WSCC for the calculation of county-wide to power plant electricity production, the TNRCC for the measured NOx and VOC data, and the ozone modeling to be performed by the Center for Energy and Environmental Resources (CEER) at the University of Texas.
[31] The use of the EPA ozone-day weather conditions and August-September 2000 Ozone Episode day is proposed to allow the EPA to assess the progress of Senate Bill 5 against the original SIP, which also used similar weather definitions to drive the photochemical model.
[32] This diversification procedure is used to develop a county-wide profile that represents the smoothed, electricity consumption of 1,000s of buildings, and consists of statistically randomized runs of the IECC-traceable simulation program.
[33] The appropriate electricity supply grid model is determined by the location of the county within the state. Depending upon where the county is located, models from ERCOT, SERC, SPP and WSCC will need to be used to determine which power plant supplied the electricity to that county, during the period of the simulation.
[34] Source: Electricity Reliability Council for Texas (ERCOT 2002).
[35] Or NOx, VOC amounts anticipated for future plants.

### 5.3.4 Calculating NOx Reductions From other County-wide area sources (ESL)

The calculated NOx and VOC sources from the electric power generation associated with IECC/IRC county-wide simulations are then merged with other sources of NOx and VOCs, including: on-road mobile, off-road mobile, area sources, biogenic and other sources. These other sources need to include anticipated decreases from other factors, including TNRCC Rule 117 that limits the NOx production of combustion sources, as well as other known, traceable reductions[36].

### 5.3.5 Procedures for Calculating Ozone Reductions From NOx Reductions (CEER)

As a final step, ozone reductions are calculated from NOx reductions traceable to the IECC/IRC implementation using the same photochemical modeling procedures[37] that were used to demonstrate the ozone reductions in the State Implementation Plan (SIP) approved by the EPA. The procedures utilize the NOx and VOC inputs from the TNRCC database, the calculated NOx and VOC reductions traceable to the IECC/IRC implementation, which are then simulated with state-wide ozone-day and August-September 2000 episode day weather conditions for Texas.

These projections of ozone reductions are then periodically compared against ozone measurements from the TNRCC measurement sites shown in Figure 27. Such measurements form the basis for classification of ozone concentrations as shown in Figure 28

[36] For example, communications several HVAC manufacturers and with GAMA have indicated that most manufacturers of residential furnaces have eliminated the pilot lights in their residential units to achieve the higher AFUE mandated by Federal law. This is estimated to be in the range of 500 to 800 Btuh of open-flame combustion per household. This becomes important when one realizes that about 5 - 10% of all households replace their furnaces in a given year, which can equal or exceed the number of new housing starts in a county. Similar reductions in pilot lights are expected for domestic water heaters and other gas appliances.
[37] The photochemical modeling performed by the Center for Energy and Environmental Resources (CEER) at the University of Texas.

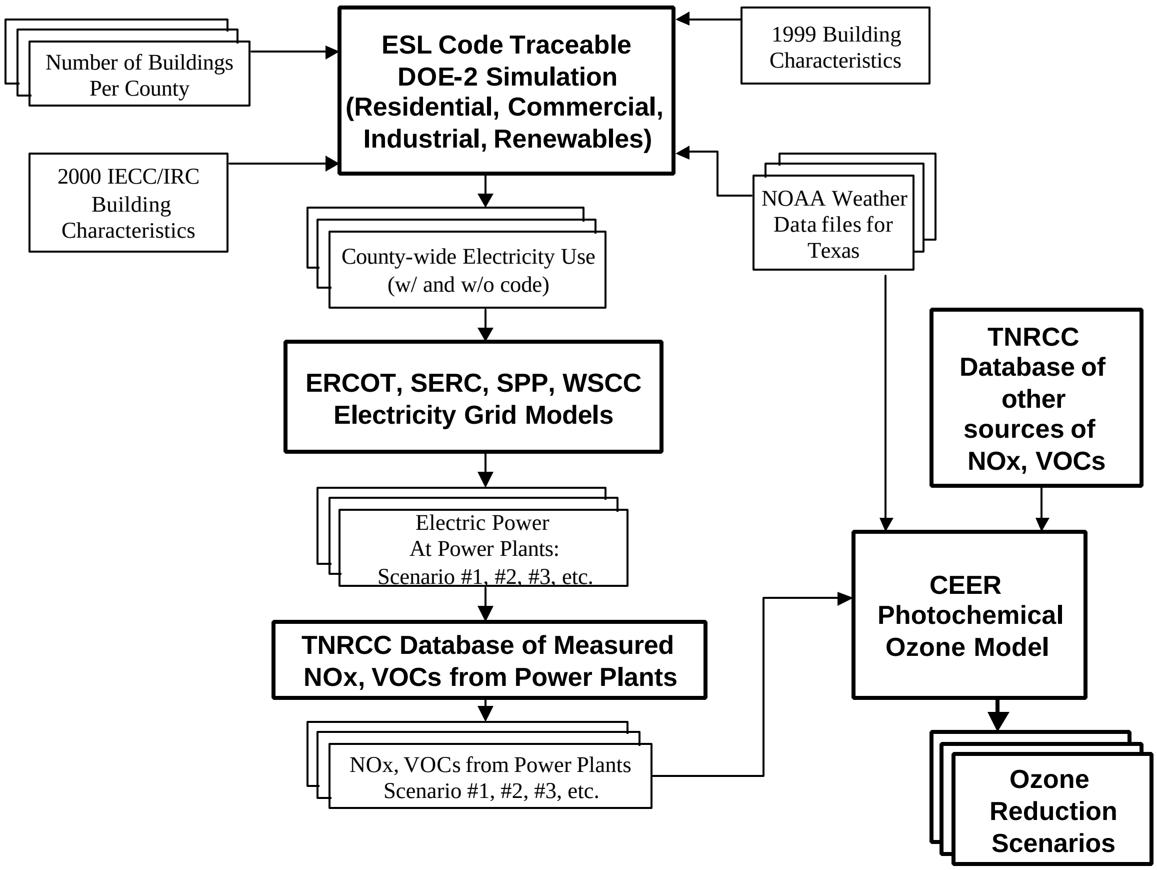


Figure 22: Analysis process for calculating emissions reductions from IECC/IRC implementation.

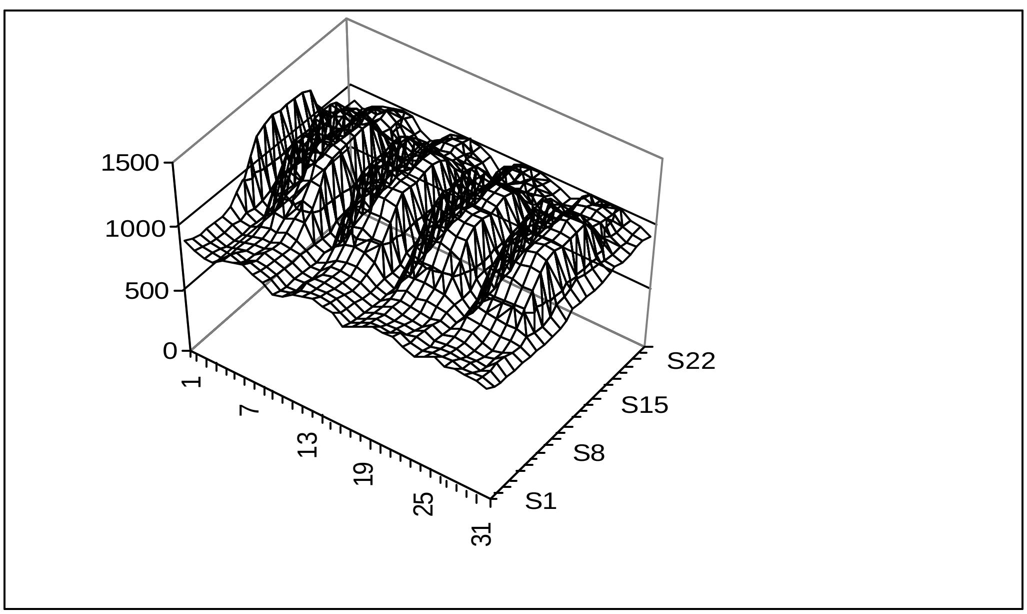


Figure 23: Example of typical county-wide, 24-hour electricity usage profile.

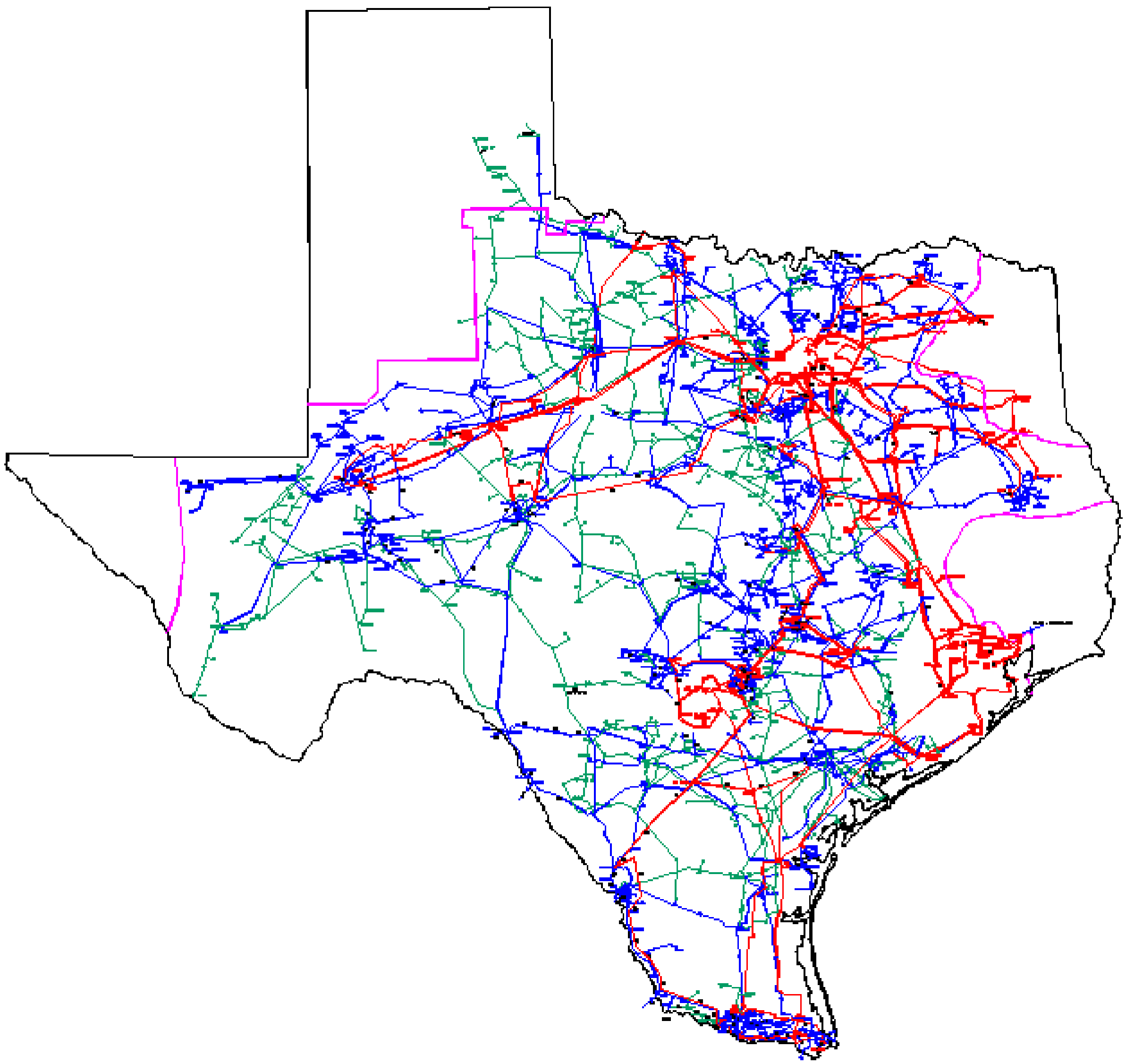

Figure 24: Texas Electricity Power Grid (Source: ERCOT 2002).

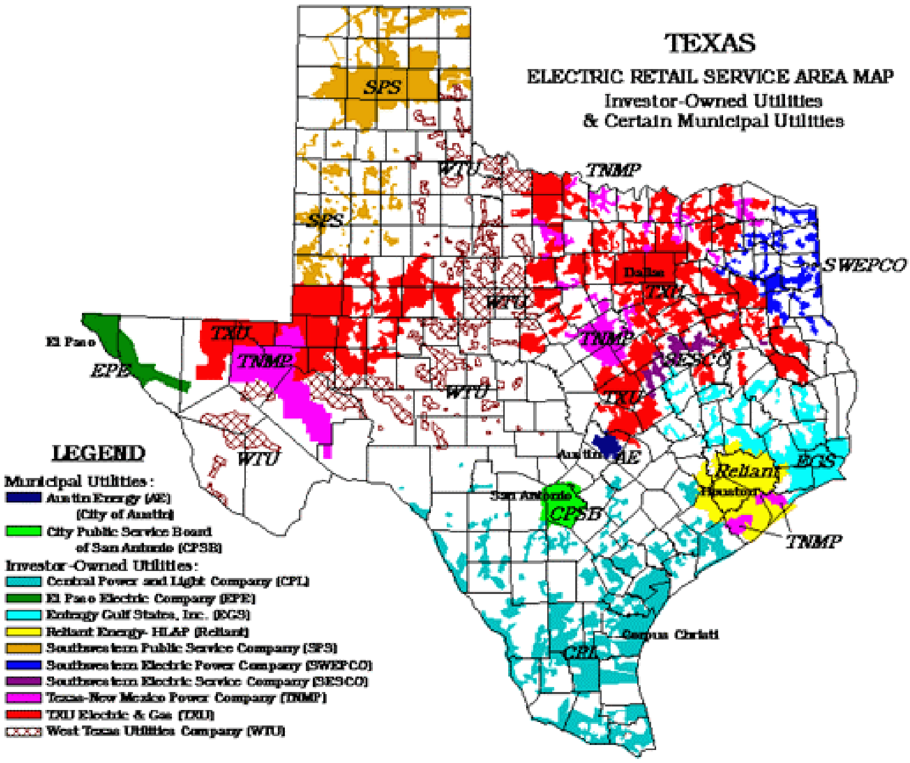


Figure 25: Texas Electric Retail Service Map (Source: TNRCC 2002).

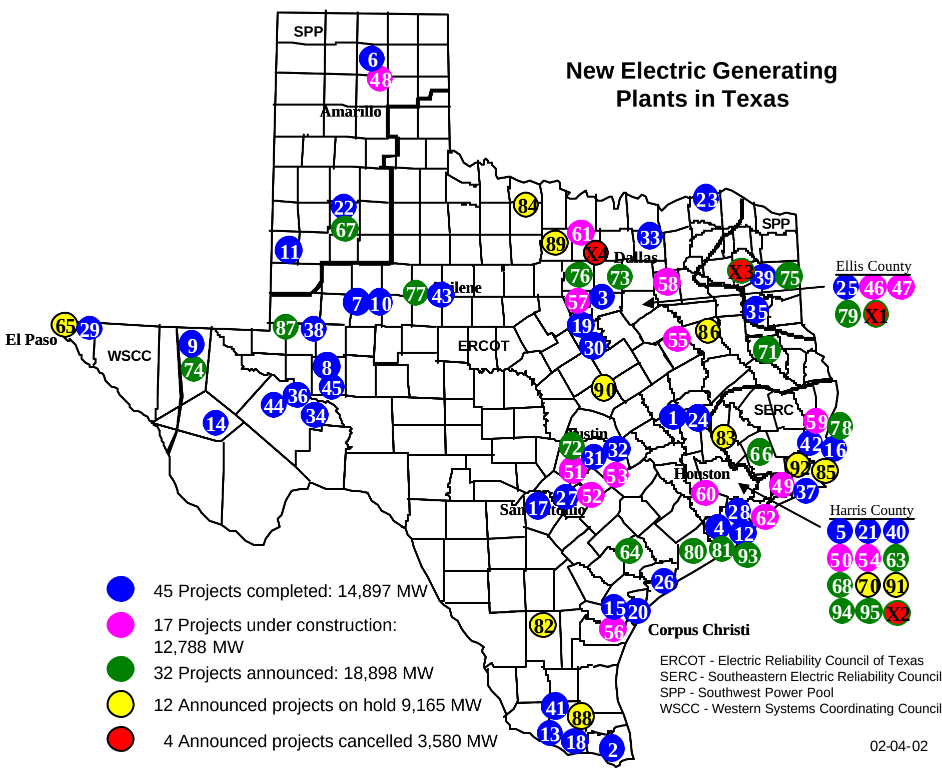


Figure 26: New Electric Generating Plants in Texas (Source: TPUC 2002).

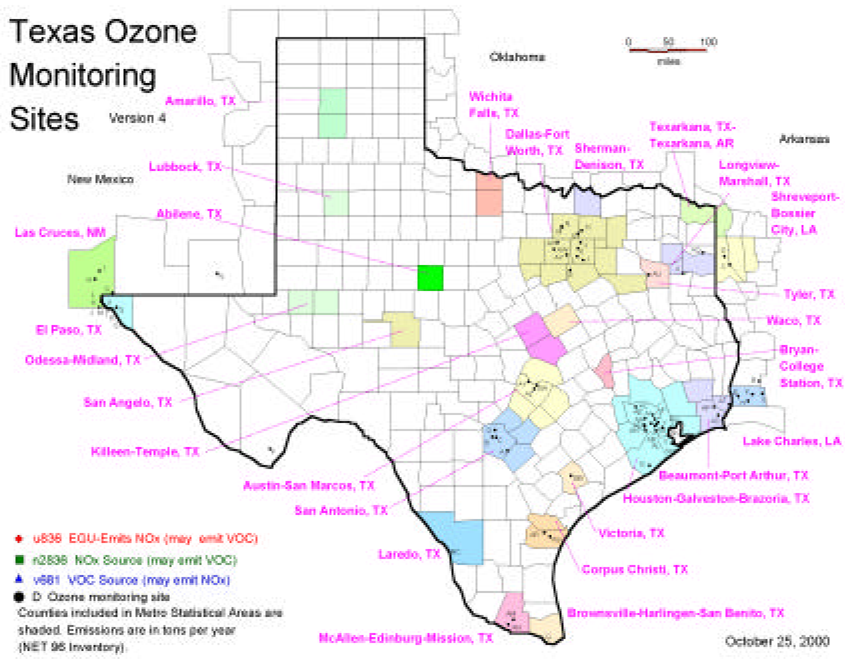


Figure 27: Texas Ozone Monitoring Sites.

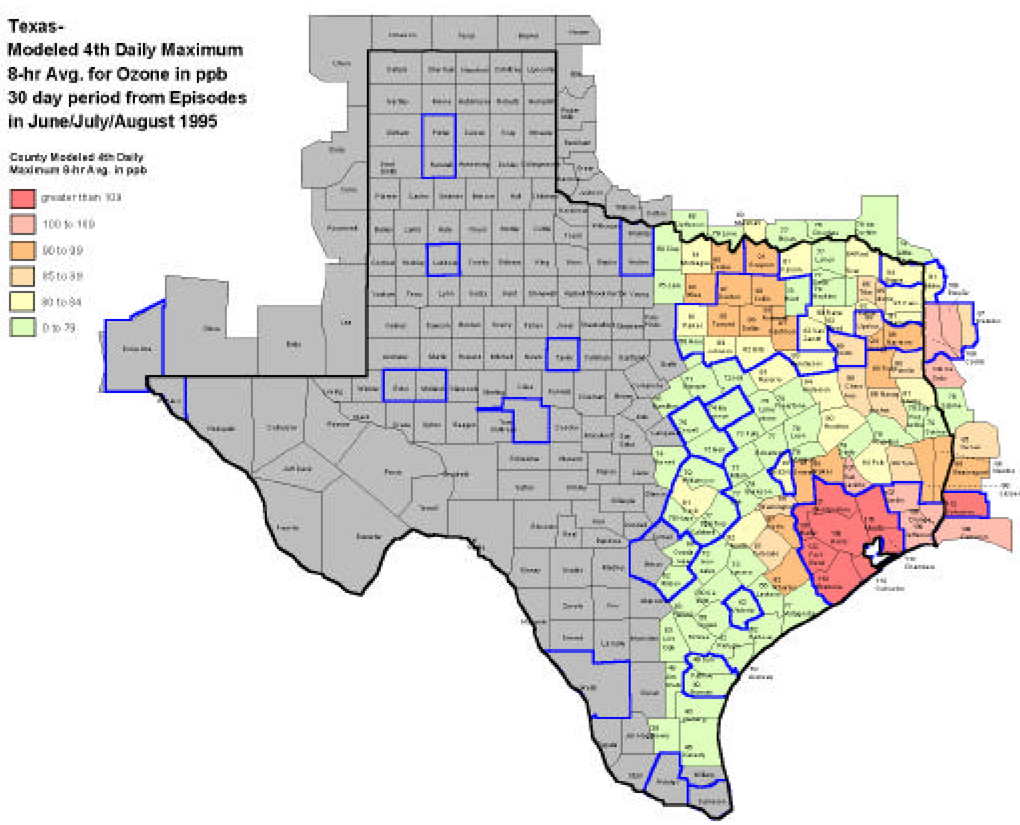


Figure 28: June/July/August 1995 Episode Day Ozone Concentrations.

# 6 TECHNOLOGY OF REDUCING ENERGY USED IN BUILDINGS

Adoption of the 2000 IECC/IRC has allowed the state of Texas to define minimum energy performance for new buildings and for existing buildings that are remodeled. In this section of this report technologies are briefly reviewed that can have a substantial impact on delivering above-code building performance for residential, commercial and industrial buildings in Texas Buildings.

In general for residential buildings, the 2000 IECC/IRC provides prescriptive measures for each climate zone in Chapters 5 and 6 to assure that new construction meets a minimum, predictable energy use. A residential performance path is provided in Chapter 4. Commercial buildings are addressed by minimum prescriptive measures in Chapter 8 of the 2000 IECC/IRC, or by minimum performance measures using ASHRAE Standard 90.1 1999[38], which is referenced by Chapter 7. More stringent design efficiency measures for commercial buildings can be found in programs such as the U.S. Green Building Council's LEED ratings[39].

## 6.1 Building Envelope

Energy efficient technologies for building envelopes include well-known technologies for insulation and newer technologies such as low-E windows, reflective roof coatings, structurally integrated panels (SIPs) and radiative barriers, as indicated in the next section.

### 6.1.1 New Construction

New construction has a many new envelope technologies for contractors and homeowners to choose from, depending upon budget, housing type and climate zone. Examples include improved low-E windows, and ventilated windows (commercial buildings), high albedo, or highly reflective roofs[40], improved shading devices for windows, which can be combined with daylighting features such as lightshelves, improved building sealing techniques such as building wraps, and sealants, reflective barriers in attics and cavities. Some residential builders are now experimenting with reducing thermal loads by reducing the exterior envelope area by using a compact two story designs that also allows for ductwork to be incorporated into the floor trusses, which reduces heat gain when compared to their traditional placement in the hot attic.

### 6.1.2 Existing Construction

Existing homes can also be improved by replacing old, single pane windows with low-E windows, installing reflective roofing, improving building infiltration using blower door testing and duct blasters, and retrofitting reflective barriers inside attics to help reduce summertime temperatures.

## 6.2 Lighting/daylighting

New technologies for reducing the energy use of lighting systems has improved dramatically in recent years. Almost daily, new energy efficient light sources appear on the store shelves for residential and

[38] Chapter 7 of the 2000 IECC/IRC, references ASHRAE Standard 90.1, 1989, which is amended to ASHRAE Standard 90.1 1999, (w/o amendments) in the 2001 Supplement (published in March 2001), which is directed by Senate Bill 5's effective date of May 1st, 2001.

[39] The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is the voluntary, consensus-based, market-driven building rating system of the U.S. Green Building Council that is used to evaluate environmental performance from a whole-building perspective over a building's life cycle and to provide a definitive standard for a "green building". Different levels of green building certification are awarded based on the total credits earned. The U.S. Green Building Council (USGBC 2002), founded in 1993, is a non-profit organization that provides knowledge and action on environmental issues for commercial and industrial buildings. The headquarters are located in San Francisco, California. The council has grown to more than 500 leading international organizations. Its goal is to help the building industry develop products that are more environmentally and economically viable and to drive the marketplace forward towards the development of high performance buildings (U.S. Green Building Council 2002).

[40] In the hot and humid south highly reflective roofs usually will require periodic washing to remove dirt, mold and mildew that can reduce the roofs thermal reflectance.

commercial applications, most notably compact fluorescents, T8 and now T5 fluorescent lamps in almost all shapes and sizes.

### 6.2.1 New Construction

Many more architects are becoming comfortable using daylighting systems that reduce lighting energy use by redirecting natural light deep into building interiors without increasing summertime heat gain. Such systems are most effective when combined with automatic dimming systems so building occupants do not have to constantly adjust the lighting levels. New systems have begun to appear that channel solar radiation, captured with sun-catchers, into building interiors using fiber optics. This same technology can provide lighting at night using a central HID source that is then channeled to luminaries through switchable fiber optics. Heat from the central HID source can then be effectively captured and reused or rejected. Lighting systems with combined motion sensors, and automatic dimming features are also becoming popular.

### 6.2.2 Existing Construction

Retrofitting existing T12 fluorescent lamps[41] with either T8 or T5 lamps is a cost effective method for reducing lighting energy use in office buildings, grocery stores, retail stores, and other facilities that currently use T12 fluorescent lighting. Such retrofits reduce the lighting energy use primarily by replacing the older magnetic ballasts[42] with new electronic ballasts that consume a fraction of the electricity use. Such lighting retrofits can also include automatic switching provided by motion sensors, lighting sensors in perimeter lighting applications or a combination of motion and lighting sensors. Reducing the installed lighting load also decreases the required cooling load, with a slight heating penalty for winter months.

## 6.3 Appliances

Energy efficient technologies for appliances vary according to application (i.e., residential or commercial) as indicated in the next section.

### 6.3.1 Residential

Significant improvements have been made in developing and delivering energy efficient refrigerators for household use, which represent a sizable portion of household electricity use. Since the mid 1980s refrigerators have made significant advances in reducing thermal losses, and improved refrigeration cycles, without significant prices increases to customers.

Other appliances in the kitchen have made efficiency improvements as well. For example, microwave ovens are in use in many kitchens that are capable of heating food with a fraction of the energy used by traditional electric or gas ovens. Convections ovens also offer some efficiency improvements over conventional ovens, as does induction (i.e., magnetic) stoves.

In the laundry room, significant energy and water savings are available with horizontal axis washing machines. Such clothes washing machines use less water, less detergent and less energy than vertical axis machines and reduce the time needed for drying because of their ability to incorporate a high-speed extraction cycle that removes additional amounts of water, which would have been removed in the dryer. Although such machines currently carry a premium price tag, reduced prices are expected as additional manufacturers offer competing models. Microwave clothes dryer R&D has also been reported by several manufacturers.

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[41] The T12 designation refers to the diameter of the fluorescent lamp, where T12 lamps would be 12/8" in diameter, T8 would be 8/8" in diameter, or 1`", and T5 lamps would be 5/8" in diameter.
[42] Lighting ballasts are necessary for fluorescent lighting to control the flow of electricity once the arc is struck between the electrodes in the lamp, which would otherwise draw an uncontrolled amount of current.

Use of the internet in a home can either increase or decrease energy use, depending several variables. Increases in energy use come from the energy used by the PC to connected to the internet, the modem used to connect to the internet (i.e., dial-up, cable or other modem), increased use of A/C or heating where none may have been used before, lighting energy use in the room, etc. Decreases in energy use come from reduced travel by the individual who is now surfing the web, versus cruising the streets in a car, and improvements in efficiency of communication using email, etc.

### 6.3.2 Commercial buildings

In commercial buildings, steadily increasing internal loads, due in part to the computerization of the office environment, have begun to level-off as LCD computer screens have become competitive with the traditional CRT displays. Increasing use of laptop computers has further reduced computer energy use. Energy efficiency has also spread to office copiers, printers, and other equipment. Teleconferencing continues to increase in use, which results in travel cost savings. Cell phones and Personal Digital Assistants (PDAs) continue to make office workers more effective workers, which can have an indirect energy savings as companies downsize, and load more clerical and administrative tasks onto their workers.

Use of the internet at work can either increase or decrease energy use, also depending several variables. Increases in energy use come from the energy used by the PC to connected to the internet, the modem used to connect to the internet (i.e., dial-up, cable or other modem), increased use of A/C or heating where none may have been used before, lighting energy use in the room, etc. Some studies have shown that employee productivity can decrease significantly if “personal” internet use at work is not closely monitored, which can indirectly affect energy. Decreases in energy use come from reduced travel by the individual who is now surfs the web to find information, versus numerous phone calls or trips to find the same information. Use of the email for distribution of sales material, brochures, etc. has also significantly decreased printing costs for many businesses, which can indirectly affect energy use.

## 6.4 Heating/Cooling Systems

Energy efficient technologies for heating and cooling systems vary according to construction type (i.e., residential, commercial, etc.). Technologies vary as well for new construction and existing construction, as indicated in the next section.

### 6.4.1 Residential: new or existing construction

Efficiency improvements in residential heating and cooling systems have also made significant contributions towards reducing household energy use. High efficiency air conditioners are now available from many manufacturers (i.e., SEER 11, 12, and 13), and when properly sized to meet the peak load, can significantly reduce summertime electricity bills. The technologies for accomplishing this vary from one manufacturer to the next, and include such innovations such as dual speed systems, variable speed systems, improved coil design (i.e., evaporator and condenser coils), air-foil technologies for improving blower efficiencies, and the ever increasing use of microprocessors similar to what has happened in the automotive industry.

Improvements to residential heating and cooling systems have also been accomplished through the introduction (or reintroduction) of new systems. Such systems include minisplits or ductless air conditioners[43], ground-coupled heat pumps, direct/indirect evaporative cooling (in the hot and dry parts of Texas). New combinations of systems can also deliver improved performance. For example, air-conditioning systems that use the domestic water heater for space heating instead of a furnace, and systems that supplement domestic water heating with waste heat recovery from the air conditioner’s condenser.

[43] A minisplit air conditioning system is similar to a window air conditioner, only the unit consists of two parts, an indoor evaporator coil/blower, and an outdoor condensing unit and compressor, connected by refrigeration and control lines. Minisplits are more common in commercial buildings, and have seen wide-spread use in other countries.

Residential furnace efficiencies have also continued to improve as well. One improvement of note for NOx reductions is the replacement of the pilot light with a hot surface ignition system. This eliminates the 500 to 800 Btu/h energy use of the pilot light[44], which contributes to the summertime ozone production if the pilot light is burning during the summertime.

Residential heating/cooling system efficiencies can also improve with the use of programmable thermostats[45]. Residential economizers are also being investigated for those climate zones where cool, dry evening conditions allow for their use[46].

Efficiency improvements have also been reported in the design of residential ductwork. Most notably, increased insulation levels, and improved sealing techniques for ductwork exposed to the severe conditions in the attic, and in several showcase homes, relocation of the ductwork and air-conditioning system inside of the conditioned envelope, usually through the use of a chase located in the ceiling of the hallway, or by using ducts that are threaded between floor trusses.

### 6.4.2 Commercial Buildings

#### 6.4.2.1 New Construction

In commercial buildings the list of technology improvement is longer. Many of these improvements rely on new or improved equipment, including: variable-volume dual or single duct systems, which use low static pressure duct distribution system, over-sized, low-head cooling towers, variable-speed chilled/hot water pumping, and high efficiency chillers, pumps, and electric motors. New blowers often utilize advanced air-foil technologies for improved efficiency. Some new systems are also being designed to minimize ductwork[47], which reduces installation costs, and improves efficiency.

Other new technologies include dual-path, pre-conditioning systems, which in the south utilize cooling coils to efficiently remove humidity from the incoming air, water-loop, ground coupled heat pumps[48], cool ceilings[49], cool beam systems [50], personal heating/cooling systems [51], thermal storage systems, and thermostats that also utilize occupancy sensors.

Significant improvements in efficiency are also being reported from the application of optimum control strategies for cooling/heating systems, most commonly where temperatures and flow rates are reduced to meet only what is required on a minute-by-minute basis. Many architects and engineers are also requiring performance testing of new construction before a building is signed-off to assure that the building meets the design and performance specifications.

#### 6.4.2.2 Existing Construction

Several important studies have shown that building heating/cooling system performance degrades over time. Such degradations decrease the system's ability to deliver comfort conditions, and more importantly to the State's emissions problems, increases the building's energy use. To help improve this problem, the

[44] 500 to 800 Btu/h is equal to about at 150 to 250 Watt light, and produces considerable NOx since the flame is an open flame.
[45] This is required by the 2000 IECC/IRC for new construction.
[46] One research effort is underway by the California Energy Commission where residential economizers are being investigated for use in low cost housing.
[47] Reducing the ductwork usually means closer coordination of the system layout during the design process. Several new buildings are being designed with ductless, under-floor distribution systems.
[48] These are being increasingly used in new K-12 schools.
[49] Cool ceilings have seen greater use in Europe where outside humidity conditions are less. Such systems are similar to radiant ceiling panels, with the difference that chilled water is circulated in the panels to keep the ceiling cool, which cools the adjacent room by radiation and convection. Such systems have improved performance because air-handling units can be downsized to ventilation air requirements (i.e., 10 to 20% of their traditional size).
[50] Cool beam systems are cooling systems where cooling coils are incorporated into the overhead lighting fixtures.
[51] Personal heating/cooling systems are often incorporated into modular office furniture systems that utilize under-floor air distribution. Improved performance is accomplished by allowing for more individualized comfort controls. Such systems also report improved user satisfaction, which is claimed to increase office productivity.

Energy Systems Laboratory developed the Continuous Commissioning$^{SM}$ or CC$^{SM}$ process. Continuous Commissioning$^{SM}$ is a process where the Laboratory staff investigates and documents areas where the performance of the mechanical systems can be improved, and working closely with the building operators, makes the changes necessary to improve performance, and documents the savings with hourly measured data. Continuous Commissioning$^{SM}$ has produced average savings in the range of 20%, and sometimes saves as much as 40% of a building's heating/cooling energy use. Many retrofit opportunities exist for commercial buildings as well, and include almost all the same measured listed for new construction. Research is also being performed at the ESL and the U.S. Department of Energy's National Laboratories to develop and test automated fault detection and diagnostics that promise to provide additional benefits from keeping a building tuned.

### 6.5 Low NOx Technologies for Building Systems

Low NOx combustion technologies for gas consuming systems in buildings vary according to construction type (i.e., residential, commercial, etc.) and include technologies for new construction and existing construction. Gas consumption in residential includes: heating systems, domestic water heating, kitchen appliances (i.e., stoves, ovens, ranges, etc.), and clothes dryers. In commercial buildings, low NOx combustion technologies are most often applied to larger boilers and furnaces that provide buildings with heating. Recently, with the advent of TNRCC rule 117, low NOx technologies are being applied to domestic water heaters.

In general, low NOx combustion technologies in residential and commercial applications rely on down-sized technology developed by the electric power generation industry, including: low NOx burners and ultra-low NOx burners. Other industrial technologies include less excess air (LEA) technologies, air staging, over fire air, fuel reburning, flue gas recirculation, water and steam rejection, reduced air preheat, combustion optimization, oxygen-enriched combustion, and catalytic combustion. Post combustion technologies include: selective non-catalytic reduction (SNCR), selective catalytic reduction (SCR), low temperature SCRs, catalysts, and other technologies[52]

### 6.6 Industrial

Opportunities for reducing energy use in industrial applications are also significant and include many of the same technologies used in commercial buildings, including: energy efficient electric motors, variable speed drives, computerized control systems, high efficiency chillers, pumps and boilers, and air-foil technologies for improving blower efficiencies. Other energy efficiency improvements have also been reported through the introduction of induction and microwave heating, cogeneration, improved steam systems, and waste heat recovery. Additional information about the numerous energy conservation opportunities for industrial applications in Texas can be found in the proceedings of the Industrial Energy Technology Conference[53].

### 6.7 Other

Significant opportunities exist for reducing energy use in other commercial applications. In the following section, opportunities in restaurants and grocery stores are briefly discussed.

#### 6.7.1 Restaurants

Significant energy efficiency improvements have been reported in the restaurant field, including the use of improved grilling equipment[54], refrigerator-freezer combinations that reduce infiltration into freezers by placing the entrance to the freezer inside the cooler, the use of industrialized, pre-prepared foods[55],

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[52] For more information about NOx reduction technologies, see the Special Report on NOx Reduction Technologies published by the Texas Institute of Advancement of Chemical Technology (TIACT 2000).
[53] The Industrial Energy Technology Conference, Energy Systems Laboratory, Texas A&M University, College Station, Texas 77843, www-esl.tamu.edu.
[54] For example the use of computerized, double-sided grills at McDonalds.
[55] For example, the use of pre-packaged salads at McDonalds.

convection ovens, combined air-conditioner/DHW heat recovery, infrared grilling, and optimal start of appliances to reduce peak electric demand[56].

### 6.7.2 Grocery Stores

Reduced energy use in grocery stores has also been reported by the major chains. Efficiency improvements have been reported through the use of refrigerator-freezer combinations, domestic water heat recovery from condensers, desiccant dehumidification from refrigeration heat rejection, rack-mounted, staged-compressors to improve refrigeration performance. T8, T5 and HID in-store lighting, and the use of daylighting.

## 6.8 Renewables

Renewable energy technologies offer significant opportunities for reducing energy use and include opportunities for solar thermal applications (i.e., active, passive), and photovoltaic (i.e., PV, BIPV).

### 6.8.1 Solar thermal systems

Solar thermal systems have most often been applied to new and existing residential and commercial to provide heating of domestic water and space heating. Such systems utilize active and passive delivery systems, where active delivery requires blowers and/or pumps. Passive delivery is usually accomplished without the use of blowers or pumps. The use of solar thermal systems to provide cooling in hot and humid climates is less used. A few installations have also reported the use of active solar systems that provide cooling to buildings using absorption or desiccant refrigeration systems. However, such systems can be expensive and require special maintenance.

### 6.8.2 Solar PV, and BIPV systems

The use of photovoltaic (PV) solar systems in residential and commercial buildings continues to grow. Installation of systems can be accomplished in new or existing sites. However, although costs have improved considerably in the last few years, the cost of such systems continues to be a restriction for wide-spread applications. Such systems can utilize grid-connected PV, independent PV, or building integrated PV (i.e., BIPV) systems. Recent advances in solar systems also include the development of combined solar thermal/PV systems. Such systems collect electricity and thermal energy from the same solar panel. In Texas, the most current information about available solar systems, and solar system installation contractors can be found by contacting the Texas Renewable Energy Industries[57] Association

## 6.9 Thermal comfort and Indoor Air Quality

Any discussion about reducing energy use in buildings in hot and humid climates is not complete without a discussion of the needs to maintain proper thermal comfort and indoor air quality. In the United States ASHRAE is the primary organization for developing and promoting standards for proper comfort conditions and indoor air quality[58]. Such standards describe acceptable conditions for thermal comfort, which include temperature and humidity conditions and ventilation requirements. In any building, sources of indoor air pollution should be reduced or placed in a controlled environment. In practice, this can be difficult and expensive to accomplish, requiring extra ducts to provide for exhaust and makeup air, special

[56] Cooking equipment in restaurants draw large amounts of electricity when they are first turned on. In many cases, the peak electric demand for a restaurant can occur in the morning when equipment is first turned-on. Staggering the start of such equipment to avoid simultaneous starting of appliances can reduce the peak monthly electric demand.

[57] The Texas Renewable Energy Industries Association can be reached at P.O. Box 16469, Austin, Texas 78761-6469, 512-345-5446, www.treia.org.

[58] Such standards include ASHRAE Standard 62-1999: Ventilation for Acceptable Indoor Air Quality, and ASHRAE Standard 55-1992: Thermal Environmental Conditions for Human Occupancy, Including ANSI/ASHRAE Addendum 55a-1995.

filtration systems (i.e., HEPA/UV systems [59]). In new commercial buildings, $CO_2$ ventilation control is being used to provide the needed fresh air, at minimum outside air levels.

# 7 PROBLEMS & NEEDS

## 7.1 Funding / Expenditures.

With the current funding situation, the majority of the Laboratory efforts are in a minimal staff, reactionary mode responding to emergencies. The Laboratory is performing the following SB5 activities.

| | |
|---|---|
| - Support training | On-going |
| - Quarterly Stakeholder meetings | On-going |
| - Respond to Municipal requests | On-going |
| - Respond to Builders, Manufacturers, Others | On-going |
| - Update Web, improve communications | On-going |
| - Support the TNRCC on the Emissions Reduction Reporting | due 6/15/02 |
| - Release HERS rating format | due 9/1/02 |

In the General Appropriations Act, the Texas Engineering Experiment Station was appropriated $1,363,060 for FY2002 and $1,293,060 for FY 2003 out of the Texas Emission Reduction Plan Fund to perform the Laboratory's responsibilities under SB5. In December of 2001, the Comptroller announced that problems in collections existed and that only approximately $58 million of the planned $276 million would be collected over the first biennium. The Laboratory's budget was then projected to be reduced to approximately $250,000 per year for the first two years. The Laboratory has currently received $105,000 through April of 2002.

Funding is crucial in order for the Laboratory to fulfill its responsibilities under SB5. With funding, the Laboratory will produce over 100 targeted training sessions per year focused on specific groups. The Laboratory would then be able to respond and effectively work with municipalities to improve their code and above code modifications in a responsive manner. The Laboratory would then be able to work with manufacturers to make sure that they understand the impact of the codes to their product lines and help assure that the required products are on the market in a timely fashion.

## 7.2 Problems/Roadblocks Experienced on TERP

### 7.2.1 Industry concerns

The key roadblock has been the lack of funding. This ripples through all activities and creates situations where the Laboratory has to focus on emergencies. In general, the cooperation and enthusiasm of all parties (including the builders/builder groups, manufacturers, public interest groups and other agencies) has been very understanding and supportive.

This lack of adequate funding has seriously slowed the Laboratory's progress in making the code adaptation a smooth process in Texas. Builders are struggling with understanding the codes and also face liability issues that they do not fully understand. Manufacturers are faced with making large tooling investments and have numerous unanswered questions on specific code requirements that impact these investment decisions. State agencies are struggling with how to acquire and validate the needed data to build the required reports to EPA.

Many of the concerns noted by industry are included in other sections of this report. These include:

- Duct insulation
- Energy Star approvals

[59] HEPA/UV systems remove indoor contaminants using filtration and sterilization using ultraviolet light.

- o Home Energy Rating Systems
- o Effective dates for provisions of this legislation
- o Detailed code issues and conflicts
- o Window issues
- o Builder training and liability issues
- o Code official ability to implement inspections
- o Lack of programmatic funding to facilitate implementation

Cost and health impacts from the adoption of the codes have also arisen as a major issue. Cost impact needs to be studied and documented. In many cases, slight changes in construction methods can result in both cost savings and improved energy efficiency. Health is directly related to moisture in the inside air (and in the walls, etc) and tightness of the house. Improvements and higher skill in designing and installing mechanical cooling and heating equipment in residences will be required as the house becomes more efficient. The Laboratory needs to demonstrate and make these methods available to Texas builders.

### 7.2.2 Technology concerns

As we go forward, methodologies will need to be developed for accurately reporting emission reductions. The Laboratory can determine the energy reductions in the municipalities and counties using a variety of methods. Ideally, we would like to have a "1-sheet" list of key code parameters on each building with its location. We will have the computer systems in place to then determine the location and quantify the energy reductions. Next, this hourly energy reduction profile needs to be tied to a particular power plant, which has specific operating conditions on NOx emissions. ERCOT data will be required for this. Finally, the reduction of hourly NOx output of the power plant needs to be put into an hourly atmospheric model (i.e., Ozone day or August-September 2000 Episode day) to determine the reduction in ozone. Although this description is overly-simplified, four groups must work closely together to accomplish this task. These are the Laboratory, TNRCC, ERCOT and the UT Atmospheric Sciences Group. This group can put a solid, defensible set of ozone reductions forward to the US EPA. The legislature could address how to allow these data to be acquired as truly needed. Deregulation of the electric utilities is also complicating the acquisition of needed data.

Additional work needs to be done in quantifying and demonstrating the cost associated with building to code standards. Cost will increase due to added insulation, higher efficiency windows, higher efficiency air-conditioners and other added items. Cost will decrease due to being able to down-size air-conditioners and furnaces and some other potential design changes like high efficiency ducts. Also, energy bills will decrease. "Back of the envelop" calculations show that the initial cost increase can be $1,000 to $2,000 or so, depending on what is done. A payback of under 3 to 5 years should be expected. Technologies are being developed to enable the first cost to be less than the old building methods, allow better comfort and improved energy efficiency. The Laboratory needs to participate in developing, demonstrating and training builders in these technologies and methods.

Along side of the cost issue is health. Homeowners are concerned with increased occurrence of asthma in children and other health related afflictions related to a "tighter" building. A tighter building can be a healthier building, if it is designed and maintained correctly. The Laboratory is ideally situated to provide the education and training on how to make the code adoption a major plus on improving the health of indoor environments.

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USGBC 2002. US Green Building Council, 110 Sutter Street, Suite410, San Francisco, CA 94101
Telephone: (415) 445-9500 Fax: (415)445-9911

# 9 APPENDIX

## 9.1 Residential Builder's Guide.

### Texas Residential Building Envelope Requirements

**Simplified Prescriptive Paths for Envelope compliance with the International Residential Code (IRC 2000)**

| Climate Zone | Path | Glazing and Insulation: Glazing Area% | Glazing U-Factor | Glazing SHGC[1] | Ceiling | Wall | Foundation Type: Floor | Basement Wall | Slab Perimeter | Crawl Space Wall |
|---|---|---|---|---|---|---|---|---|---|---|
| 9 (4,000-4,499 HDD[3]) | 1 | 15 | .45 | N/S | R-38 | R-13 | R-19 | R-8 | R-5, 2ft | R-11 |
| | 2 | 20 | .37 | N/S | R-38 | R-13 | R-19 | R-9 | R-6, 2ft | R-13 |
| | 3 | 25 | .37 | N/S | R-38 | R-19 | R-19 | R-9 | R-6, 2ft | R-13 |
| 8 (3,500-3,999 HDD) | 1 | 15 | .50 | N/S | R-30 | R-13 | R-19 | R-8 | R-5, 2ft | R-10 |
| | 2 | 20 | .42 | N/S | R-38 | R-13 | R-19 | R-8 | R-6, 2ft | R-10 |
| | 3 | 25 | .41 | N/S | R-38 | R-19 | R-19 | R-8 | R-6, 2ft | R-10 |
| 7 (3,000-3,499 HDD) | 1 | 15 | .55 | .40 | R-30 | R-13 | R-19 | R-7 | [2]R-4, 2ft | R-8 |
| | 2 | 20 | .46 | .40 | R-38 | R-13 | R-19 | R-7 | R-0 | R-8 |
| | 3 | 25 | .45 | .40 | R-38 | R-19 | R-19 | R-7 | R-0 | R-8 |
| 6 (2,500-2,999 HDD) | 1 | 15 | .60 | .40 | R-30 | R-13 | R-19 | R-6 | [2]R-4, 2ft | R-7 |
| | 2 | 20 | .50 | .40 | R-38 | R-13 | R-19 | R-6 | R-0 | R-7 |
| | 3 | 25 | .46 | .40 | R-38 | R-16 | R-19 | R-6 | R-0 | R-7 |
| 5 (2,000-2,499 HDD) | 1 | 15 | .65 | .40 | R-30 | R-13 | R-11 | R-5 | R-0 | R-6 |
| | 2 | 20 | .52 | .40 | R-38 | R-13 | R-11 | R-5 | R-0 | R-6 |
| | 3 | 25 | .50 | .40 | R-38 | R-13 | R-19 | R-8 | R-0 | R-10 |
| 4 (1,500-1,999 HDD) | 1 | 15 | .75 | .40 | R-26 | R-13 | R-11 | R-5 | R-0 | R-5 |
| | 2 | 20 | .60 | .40 | R-30 | R-13 | R-11 | R-5 | R-0 | R-5 |
| | 3 | 25 | .52 | .40 | R-30 | R-13 | R-13 | R-6 | R-0 | R-6 |
| 3 (1,000-1,499 HDD) | 1 | 15 | .75 | .40 | R-19 | R-11 | R-11 | R-0 | R-0 | R-5 |
| | 2 | 20 | .70 | .40 | R-30 | R-13 | R-11 | R-0 | R-0 | R-5 |
| | 3 | 25 | .55 | .40 | R-30 | R-13 | R-11 | R-0 | R-0 | R-5 |
| 2 (500-999 HDD) | 1 | 15 | .90 | .40 | R-19 | R-11 | R-11 | R-0 | R-0 | R-4 |
| | 2 | 20 | .75 | .40 | R-30 | R-13 | R-11 | R-0 | R-0 | R-4 |
| | 3 | 25 | .65 | .40 | R-30 | R-13 | R-11 | R-0 | R-0 | R-4 |

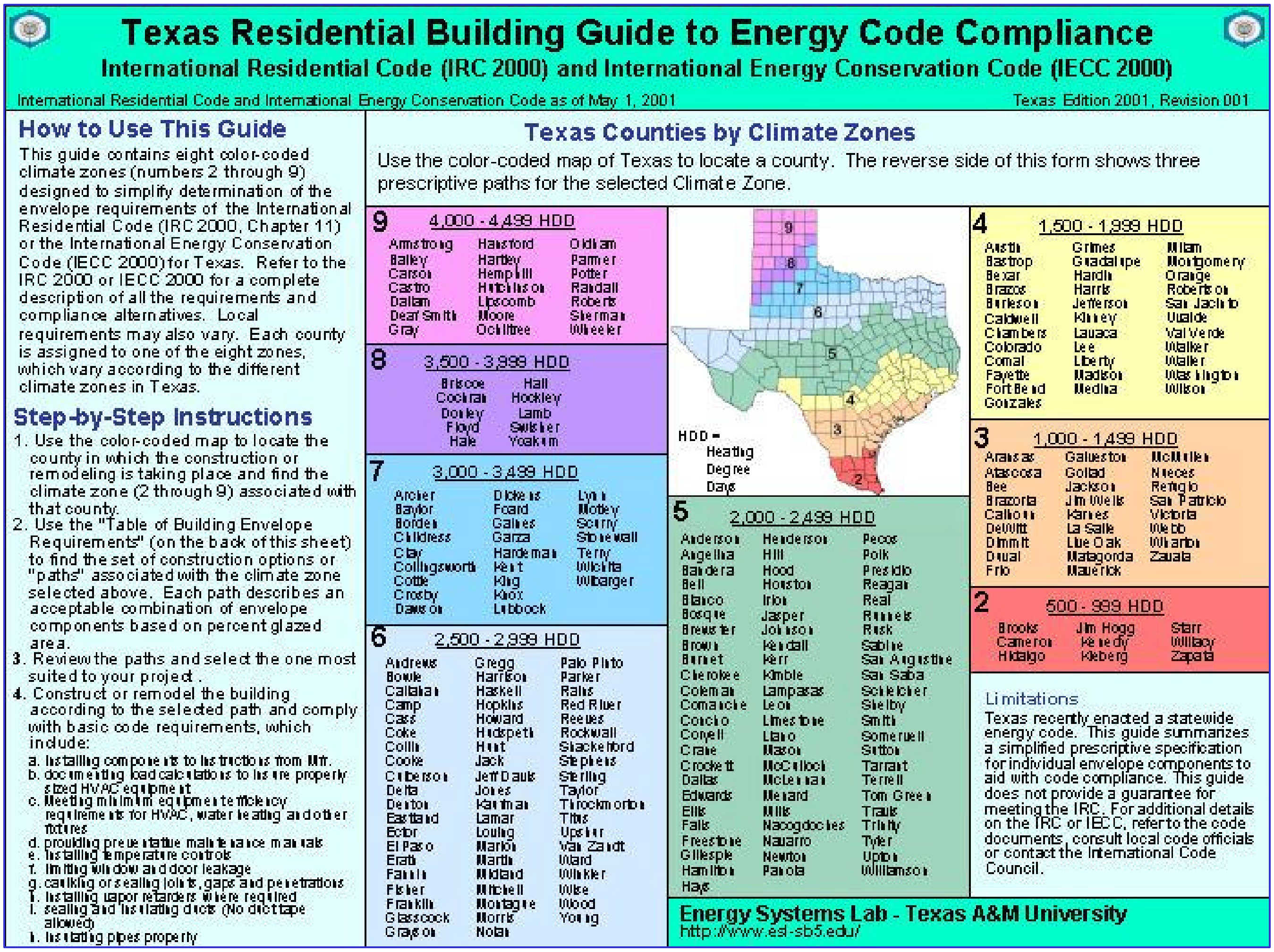
[1]N/S means "not specified". Calculations done using IECC Chap. 4 use a SHGC of .68 for the standard case.
[2]The map in IRC Figure R301.2(6) indicates that parts of Texas qualify as areas of "very heavy" termite infestation probability. Under an exception in the IRC, the slab perimeter insulation requirement in this path may be avoided. To make use of this exception and still comply with the Code, a builder must use IECC Section 502.2.1.4, IECC Section 502.2.4, or IECC Chapter 4, instead of this path.
[3]HDD = Heating Degree Days

**Notes:**

1. This table of building envelope requirements is based upon the 2000 International Residential Code (IRC), published by the International Code Council.
2. The IRC prescriptive requirements are applicable to homes with glazing areas of 15% and below. For homes designed with glazing areas greater than 15%, the IRC incorporates the International Energy Conservation Code (IECC) by reference, which contains additional prescriptive and performance-related compliance alternatives.
3. Source of requirements: 2000 IRC, Ch. 11 (up to 15% only) and 2000 IECC, Ch. 5, Prescriptive Packages for Climate Zones 2-9.
4. Window area %, U-factor, and SHGC are maximum acceptable levels.
5. Insulation R-values are minimum acceptable levels.
6. Applies to single-family, wood-frame residential construction, only. For mass wall construction, see IRC Section N1102.1.1.1; for steel-framed walls, see IRC Section N1102.1.1.2.
7. "Glazing" refers to any translucent or transparent material in exterior openings of buildings, including windows, skylights, sliding glass doors, the glass areas of opaque doors, and glass block.
8. Fenestration product (window, door, glazing) U-factor and SHGC must be determined from a National Fenestration Rating Council (NFRC) label on the product, or obtained from default tables (IECC Table 102.5.2(3) in Chapter 1).
9. Glazing area % is the ratio of the area of the rough opening of windows to the gross wall area, expressed as a percentage. Up to one percent of the total window area may be exempt from the U-factor requirement.
10. Opaque doors are not considered glazing (or "windows") and must have a maximum U-factor of 0.35. One exempt door allowed.
11. Infiltration requirements: Windows ≤ 0.30 cfm per sq.ft. of window area; doors ≤ 0.30 cfm per sq.ft. of door area (swinging doors below 0.50 cfm); determined in accordance with AAMA/WDMA 101/I.S.2 (must be tested and labeled in accordance with ASTM E 283).
12. R-2 shall be added to the requirements for slab insulation where uninsulated hot water pipes, air distribution ducts or electric heating cables are installed in or under the slab.
13. Floors over outside air must meet ceiling insulation requirements.
14. R-values for walls represent the sum of cavity insulation plus insulated sheathing, if any.
15. Prescriptive packages are based upon meeting or exceeding minimum equipment efficiencies for HVAC and water heating (IECC Table 503.2).



Figure 29: Example of the Laboratory's Builder's Guide available for distribution via the web and on laminated cardstock (page 1).



# Texas Residential Building Guide to Energy Code Compliance

## International Residential Code (IRC 2000) and International Energy Conservation Code (IECC 2000)

International Residential Code and International Energy Conservation Code as of May 1, 2001 — Texas Edition 2001, Revision 001

### How to Use This Guide

This guide contains eight color-coded climate zones (numbers 2 through 9) designed to simplify determination of the envelope requirements of the International Residential Code (IRC 2000, Chapter 11) or the International Energy Conservation Code (IECC 2000) for Texas. Refer to the IRC 2000 or IECC 2000 for a complete description of all the requirements and compliance alternatives. Local requirements may also vary. Each county is assigned to one of the eight zones, which vary according to the different climate zones in Texas.

### Step-by-Step Instructions

1. Use the color-coded map to locate the county in which the construction or remodeling is taking place and find the climate zone (2 through 9) associated with that county.
2. Use the "Table of Building Envelope Requirements" (on the back of this sheet) to find the set of construction options or "paths" associated with the climate zone selected above. Each path describes an acceptable combination of envelope components based on percent glazed area.
3. Review the paths and select the one most suited to your project.
4. Construct or remodel the building according to the selected path and comply with basic code requirements, which include:
   a. installing components to instructions from Mfr.
   b. documenting load calculations to insure properly sized HVAC equipment
   c. Meeting minimum equipment efficiency requirements for HVAC, water heating and other fixtures
   d. providing preventative maintenance manuals
   e. installing temperature controls
   f. limiting window and door leakage
   g. caulking or sealing joints, gaps and penetrations
   h. installing vapor retarders where required
   i. sealing and insulating ducts (No duct tape allowed)
   j. insulating pipes properly

### Texas Counties by Climate Zones

Use the color-coded map of Texas to locate a county. The reverse side of this form shows three prescriptive paths for the selected Climate Zone.

**9** 4,000 - 4,499 HDD
Armstrong, Bailey, Carson, Castro, Dallam, Deaf Smith, Gray, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Parmer, Potter, Randall, Roberts, Sherman, Wheeler

**8** 3,500 - 3,999 HDD
Briscoe, Cochran, Donley, Floyd, Hale, Hall, Hockley, Lamb, Swisher, Yoakum

**7** 3,000 - 3,499 HDD
Archer, Baylor, Borden, Childress, Clay, Collingsworth, Cottle, Crosby, Dawson, Dickens, Foard, Gaines, Garza, Hardeman, Kent, King, Knox, Lubbock, Lynn, Motley, Scurry, Stonewall, Terry, Wichita, Wilbarger

**6** 2,500 - 2,999 HDD
Andrews, Bowie, Callahan, Camp, Cass, Coke, Collin, Cooke, Culberson, Delta, Denton, Eastland, Ector, El Paso, Erath, Fannin, Fisher, Franklin, Glasscock, Grayson, Gregg, Harrison, Haskell, Hopkins, Howard, Hudspeth, Hunt, Jack, Jeff Davis, Jones, Kaufman, Lamar, Loving, Marion, Martin, Midland, Mitchell, Montague, Morris, Nolan, Palo Pinto, Parker, Rains, Red River, Reeves, Rockwall, Shackelford, Stephens, Sterling, Taylor, Throckmorton, Titus, Upshur, Van Zandt, Ward, Winkler, Wise, Wood, Young



**5** 2,000 - 2,499 HDD
Anderson, Angelina, Bandera, Bell, Blanco, Bosque, Brewster, Brown, Burnet, Cherokee, Coleman, Comanche, Concho, Coryell, Crane, Crockett, Dallas, Edwards, Ellis, Falls, Freestone, Gillespie, Hamilton, Hays, Henderson, Hill, Hood, Houston, Irion, Jasper, Johnson, Kendall, Kerr, Kimble, Lampasas, Leon, Limestone, Llano, Mason, McCulloch, McLennan, Menard, Mills, Nacogdoches, Navarro, Newton, Panola, Pecos, Polk, Presidio, Reagan, Real, Runnels, Rusk, Sabine, San Augustine, San Saba, Schleicher, Shelby, Smith, Somervell, Sutton, Tarrant, Terrell, Tom Green, Travis, Trinity, Tyler, Upton, Williamson

**4** 1,500 - 1,999 HDD
Austin, Bastrop, Bexar, Brazos, Burleson, Caldwell, Chambers, Colorado, Comal, Fayette, Fort Bend, Gonzales, Grimes, Guadalupe, Hardin, Harris, Jefferson, Kinney, Lavaca, Lee, Liberty, Madison, Medina, Milam, Montgomery, Orange, Robertson, San Jacinto, Uvalde, Val Verde, Walker, Waller, Washington, Wilson

**3** 1,000 - 1,499 HDD
Aransas, Atascosa, Bee, Brazoria, Calhoun, DeWitt, Dimmit, Duval, Frio, Galveston, Goliad, Jackson, Jim Wells, Karnes, La Salle, Live Oak, Matagorda, Maverick, McMullen, Nueces, Refugio, San Patricio, Victoria, Webb, Wharton, Zavala

**2** 500 - 999 HDD
Brooks, Cameron, Hidalgo, Jim Hogg, Kenedy, Kleberg, Starr, Willacy, Zapata

### Limitations

Texas recently enacted a statewide energy code. This guide summarizes a simplified prescriptive specification for individual envelope components to aid with code compliance. This guide does not provide a guarantee for meeting the IRC. For additional details on the IRC or IECC, refer to the code documents, consult local code officials or contact the International Code Council.

**Energy Systems Lab - Texas A&M University**
http://www.esl-sb5.edu/

Figure 30: Example of the Laboratory's Builder's Guide available for distribution via the web and on laminated cardstock (page 2).

9.2 Code Compliance Form for Residential Areas.

# Texas Building Energy Efficiency Code Compliance Form For Residential Buildings in Unincorporated Areas

Effective Date: 9/1/2002

Texas law requires the person building a new residential structure to comply with the Texas Building Energy Efficiency Code (International Residential Code ("IRC") and/or International Energy Conservation Code ("IECC") as it existed on May 1, 2001) pursuant to Health and Safety Code Section 388.003 (single or multifamily units, three floors and under).

Common Address or Legal Description: ______________________________
__________ County: ______________________
This residence (select one of the following options):
__ 1. Has been compliance certified by a national, state, or local accredited energy efficiency program;
__ 2. Has been compliance certified from a private code-certified inspector using the IRC's Energy Efficiency Chapter (Chapter 11) or the IECC; or
__ 3. Has been built to include the following energy efficiency elements: (If this option is selected, complete the following 5 categories and provide any additional necessary information)

**(1) Insulation values (R-value of insulation installed) for each of the following:**

Framing material (check one): Wood Steel Mass Wall or Other (specify):
Attic ....................(R-value) _______
Cathedral ceiling ................ (R-value) ________
Opaque walls .......(R-value) _______ Floors over unheated spaces..... (R-value) _______
Floors over outside air ...... (R-value) _______Ducts (outside conditioned space (R-value) _______
Foundation type:Slab-on-grade ........................ (R-value) _______ (Depth):
Crawlspace ............................ (R-value) _______ (Depth):
Basement (R-value, if applicable): ________ (Depth):
(Interior/Exterior):
Percent of basement walls underground ______ %Area of "very heavy termite infestation" (yes/no)

**(2) Ratings of windows and doors for each of the following:**

Glazing area percentage: ______________ %
(ratio of the area of the rough opening of glazing to the gross wall area)
Glazed door(s) (sliding or hinged) .......(U-factor) ________ (SHGC) __________
Other exterior doors .........................(U-factor) ________ (SHGC) __________
Windows (determined from NFRC rating):
(U-factor) ___________ ____________ ____________
(SHGC) ___________ ____________ ____________
(Air Infiltration) ___________ ____________ ____________

**(3) HVAC equipment efficiency levels:**

Heating systems:Gas fired forced air furnace ......................... (AFUE rating) ___________
Electric heat pump ..................................... (HSPF rating) ___________

Version 1.0, November 20, 2001 Page 1 of 2

Figure 31: Example of the Laboratory's self-certification form for code compliance in unincorporated areas (front).

# Texas Building Energy Efficiency Code Compliance Form For Residential Buildings in Unincorporated Areas

Effective Date: 9/1/2002

Air conditioning systems: Electric unit ..............................(SEER rating) ____________
Electric heat pump ................ (EER rating) ____________
Ground source heat pump ....... (EER rating) ____________

**(4) Water heating efficiency levels:** Water heater fuel type ................. ____________
Water heater capacity ..................................____________
NAECA energy factor ..................................____________

**(5) Basic requirements** (*check to indicate the measures you have completed or write "N/A" if in applicable*):

Air-tight recessed lights (ASTM E 283): _________ U.L. 181 duct sealing products (or mastics): _____
Air sealed penetrations/gaps/holes, etc.: _________ Shower heads rated at 2.5gpm/80psi: _________
HVAC piping insulation: ________________ Circulating hot-water piping insulation: _______
Multi-family units separately metered: _________ Thermostats for each system: ____________
Heat pump thermostat: ________________ Equipment maintenance information: _________
Vapor retarders: ____________ (where installed: ________________________________)

**Additional Information:** *(attach additional sheet if necessary)* __________________

______________________________________________________________

______________________________________________________________

## Complete the following Certification, as applicable:

**Accredited energy efficiency program:**______________________________

**Inspector name/address:**____________________________________________

______________________________________________________________

**Inspector certified by:** ---------______________________ **Certification number:** __________

**Builder or Seller name/address:** ___________________________________________

**Builder or Seller signature:** __________________________ **Date:** ________________

**Buyer signature(s):** ________________________________ **Date:** ________________

**Inspector signature:** ----------______________________________ **Date:** ____________

*This form may be reproduced-Form available from: Texas A&M University Energy Systems Laboratory, Weisenbaker Hall, College Station, Texas; or on the Internet at http://www-esl.tamu.edu/index.html*
*Telephone: (979) 862-2775, Facsimile (979) 862-8687*

Version 1.0, November 20, 2001 Page 1 of 2

Figure 32: Example of the Laboratory's self-certification form for code compliance in unincorporated areas (back).

9.3 Senator Brown's letter of intent regarding R8 flex duct.

**Energy Systems Laboratory**
Texas Engineering Experiment Station
Texas A&M University System
3581 TAMU
College Station, Texas 88743-3581

Date: March 8, 2002

To: Concerned Individuals and Companies In Texas

Subject: Use of R-6 Instead of R-8

Based on the attached legislative intent issued by Senator "Buster" Brown, it is the opinion of the Energy Systems Laboratory that R-6 insulated flexible duct may be substituted for the IECC required R-8 duct until February 1, 2003.

If any further information is required, please call the Energy Systems Laboratory toll free at 877-AnM-CODE (877-266-2633).

Sincerely yours,

Charles Culp / Bahman Yazdani

Figure 33: Laboratory's letter to builders regarding the R8 flexible duct issue (page 1).

March 1, 2002

Charles Culp, P.E., Ph.D. & Bahman Yazdani, P.E.
Associate Directors, Energy Systems Lab
Texas Engineering Experiment Station
Texas A&M University
214 Wisenbaker Engineering Res. Ctr.
3581 TAMU
College Station, TX 77843-3581

Re: Legislative intent for use of R8 flexible duct

Dear Dr. Culp & Mr. Yazdani:

Please allow this letter to serve as a written statement of my legislative intent regarding the implementation date for the required use of R8 flexible duct as stated in Senate Bill 5, 77th Legislature. The intended date for use of R8 flexible duct is February 1, 2003.

An exception to use R6 insulated duct in lieu of the R8 duct code requirement should be allowed for until February 1, 2003. This should help clarify confusion when R6 duct is used within the existing code requirements until that date.

The following scientific-based explanations provided by your technical staff at the Texas A&M University Energy Systems Laboratory (TAMU ESL) give further support to the intended date of compliance for all communities within Texas:

> The International Energy Conservation Code (IECC) of 2001 requires that R8 flexible duct be used in place of lower R-rated insulated duct, when ducts are in unconditioned spaces. Although R6 duct is widely and economically available, R8 insulated flexible duct is not at this time. Limited supplies are available from one manufacturer but not in the quantities needed to satisfy the

Figure 34: Senator Brown's letter to the Laboratory regarding the R8 flexible duct issue (page 1).

requirements for the homes in municipal areas.

> Chapter 11 of the International Residents Code (IRC) code specifically allows R5 or higher in homes with up to 15% window to wall area. The IECC requires R8 for above 15% window to wall area. Situations where code inspectors have not allowed R6 duct in housing where the window to wall area is under 15% have been reported, undoubtedly due to confusion and inadequate training.
>
> Technically, R6 insulated flexible duct causes minimal decrease in efficiency except when used in unconditioned attics. Use of R6 duct will result in a few percent loss of efficiency for the cooling system. Improper installation of either R6 or R8 that causes leakage will result in a much greater loss of system efficiency.

As the author of Senate Bill 5, I am also requesting that the TAMU ESL expand the focus of the code training workshops to cover additional detail on the correct installation of this duct, and that the TAMU ESL survey and work with flexible duct manufacturers to prepare to deliver the needed quantities of R8 duct at competitive prices over the next seven months then report to the Senate Natural Resources Committee by September 1, 2002.

Sincerely,

JEB:ww

cc: Texas Association of Builders
Texas Association of General Contractors
Associated General Contractors

Figure 35: Senator Brown's letter to the Laboratory regarding the R8 flexible duct issue (page 2).

9.4 Proposed NTCOG Amendments to the 2000 IECC.

-----Original Message-----
From: Jennifer Crosby [mailto:jcrosby@dfwinfo.com]
Sent: Monday, March 18, 2002 4:18 PM
To: 'Al Godwin' (E-mail); Bill Elliott (E-mail); Charles Bloomberg (E-mail); David Session (E-mail); Dennis Pitts (E-mail); Ed Dryden (E-mail); Jack Craycroft (E-mail); Jack Thompson (E-mail); 'James Johns' (E-mail); Jim Olk (E-mail); 'Joe Pierce' (E-mail); Karen Makarem (E-mail); Larry King (E-mail); Leo Stambaugh (E-mail); Mark Hightower (E-mail); Ravi Shah (E-mail); Robert Younger (E-mail); Ronnie Frazier (E-mail); Russ Mower (E-mail); Scott Williams (E-mail); Si McHugh (E-mail); Tim Dovel (E-mail); Tom Fitzpatrick (E-mail); Tom Smith (E-mail); Tommy Jackson (E-mail)
Cc: Kenny Calhoun
Subject: Response Requested - Energy Amendment Revisions

To the Building & Energy Advisory Board:

Please review the minor revisions made in the attached Amendments to the 2000 IECC and Chapter 11 of the 2000 IRC. These revisions were made based on comments received from the Energy Systems Laboratory in January (please see http://www.dfwinfo.com/envir/coordinated/regcodes/2001Amend/ESLresponse.html for full text of the ESL's comments).

Please vote on whether or not you approve of these revisions by responding to this email by 12:00 PM Friday, March 22. The changes require approval from a minimum of 2/3 of the board to be instituted.

Summary of Revisions:
* Chapter 11 of the IRC - one change on page 2
* IECC - two changes on page 2

If you have any questions, please contact me. Thanks!
<<2000 IRC amendments-Chapter 11 ESL.doc>> <<2000 IECC amendments ESL.doc>>

Jenny Crosby
Environmental Planner
North Central Texas Council of Governments
P.O. Box 5888 Arlington, TX 76005-5888
Voice: 817-695-9108 Fax: 817-695-9191

Recommended Amendments to the
2000 International Energy Conservation Code
North Central Texas Council of Governments region

**Section 101.3; amend as follows:
101.3 Compliance. Compliance with this code shall be determined in accordance with Sections 101.3.1, ~~and~~ 101.3.2, or 101.3.3.
**Add the following item:
101.3.3. Alternative compliance. A building certified through a voluntary energy performance testing program approved as meeting or exceeding the provisions of this code may be deemed to comply with the requirements of this code.

(Reason: This amendment would encourage participation in above-code programs and provide an attractive alternative path for unconventional builders who are committed to quality and efficiency, but concerned about mechanics of code compliance. NCTCOG will arrange advisory review of such programs.)

**Section 302.1; Replace blank Table 302.1 Exterior Design Conditions with the following:

| CONDITION | VALUE |
|---|---|
| Winter [a], design dry-bulb ($^oF$) (99.6%) | 17 |
| Summer [a], design dry-bulb ($^oF$) (0.4%) | 100 |
| Summer [a], design wet-bulb ($^oF$) (0.4%) | 78 |
| Degree days heating [b] | 2407 |
| Degree days cooling [b] | 2603 |
| Climate zone [c] | 5B |

**Delete note "a" and replace with the following:
a. These values are from ASHRAE Handbook of Fundamentals for Dallas/Ft. Worth International Airport 99.6% Winter DB, 0.4% Summer DB, and 0.4% Summer WB; and from Local Climatological Data for Dallas-Ft. Worth published by the National Climatic Data Center, National Oceanic and Atmospheric Administration. These values are for the purpose of providing a uniform basis of requirements for North Central Texas. This will not preclude licensed professionals from submitting design analyses based on site measurements or published data more specific to the building site. Adjustments shall be permitted to reflect local climates which differ from the tabulated values, or local weather experience determined by the code official.

(Reason: One of the references in note "a" is in error. The 1997 ASHRAE Handbook of Fundamentals no longer publishes the design temperature tables in the format assumed by this reference. The main purpose of this change, however, is to provide typical design data for the NCTCOG region for ease of reference within this code.)

**Delete Figures 302.1 (1-43, 45-51).

(Reason: There is no need to reference the maps of other states.)

**Section 502.1.1; delete exception #2 and substitute the following:
2. Buildings located in Climate Zones 5 through 6 as indicated in Table 302.1.

(Reason: This would eliminate the requirement of a vapor retarder throughout the NCTCOG region. Eliminating vapor retarders in hot and humid climate zones is consistent with the recommendation of most building scientists.)

**Section 502.1.5; add the following exceptions:

Exceptions:

1. Any glazing facing within 45 degrees of true north;
2. Any glazing facing within 45 degrees of true south which is shaded along its full width by a permanent overhang with a projection factor of 0.3 or greater.
3. Any fenestration with attached screens where the screens have a rated shading coefficient of .6 or less.

(Reason: This will allow north facing windows, which do not receive direct solar radiation, to be exempt from the minimum SHGC requirement; provides a simple way for south facing windows to effectively achieve summer shade and still receive some solar heat benefit in winter; and specifically allows use of solar screens to achieve the shading effect.)

**Section 502.2; Replace blank Table 502.2 Heating & Cooling Criteria with the following:

Table 502.2[a,g]
HEATING AND COOLING CRITERIA

| Element | Mode | Type A-1 Residential Buildings $U_o$ | Type A-2 Residential Buildings $U_o$ |
|---|---|---|---|
| Walls | Heating or cooling | 0.15 | 0.22 |
| Roof/ceiling | Heating or cooling | 0.03 | 0.03 |
| Floors over unheated spaces | Heating or cooling | 0.05 | 0.05 |
| Heated slab on grade | Heating | R-value = 6 | R-value = 6 |
| Unheated slab on grade | Heating | R-value = 0 | R-value = 0 |
| Basement wall | Heating or cooling | U-factor = 0.15 | U-factor = 0.15 |
| Crawl space wall | Heating or cooling | U-factor = 0.15 | U-factor = 0.15 |

**Delete Note "a" and replace with the following:
a. The above values have been determined for all counties in the North Central Texas Council of Governments region.
**Add Note "g":
g. These requirements apply only to the boundaries of conditioned space. Air conditioning equipment and ductwork is recommended, but not required, to be located within the conditioned space in North Central Texas zones.
**Delete Figures 502.2(1-6)

(Reason: This change unifies the requirements for all counties within the North Central Texas COG. Reference to the graphs is no longer needed when the values have been specified.)

**Section 502.2; Add note to Fig 502.2(7):
All counties within the North Central Texas Council of Governments region are designated as within the area of very heavy termite infestation probability for purpose of uniform interpretation of this requirement.

(Reason: This allows for uniform interpretation of the map throughout the area of the COG.)

**Section 502.2.4; Delete prescriptive Tables 502.2.4(1-9) and substitute the following:
**Replace Tables 502.2.4 (1-6) with:
Table 502.2.4(1)
Prescriptive Building Envelope Requirements, Type A-1 Residential Buildings, Based on Window Area as a Percent of Gross Exterior Wall Area (for zones 5b and 6b)

| % Glazing | Maximum | Minimum | | | | | |
|---|---|---|---|---|---|---|---|
| | Glazing U-factor | Ceiling R-value | Exterior wall R-value | Floor R-value | Basement wall R-value | Slab perimeter R-value and depth | Crawl space wall R-value |
| ≤8% | 0.70 | R-26 | R-11 | R-11 | R-5 | R-0 | R-6 |
| ≤12% | 0.65 | R-26 | R-13 | R-11 | R-5 | R-0 | R-5 |
| ≤15% | 0.65 | R-30 | R-13 | R-11 | R-6 | R-0 | R-7 |
| ≤18% | 0.52 | R-30 | R-13 | R-19 | R-6 | R-0 | R-7 |
| ≤20% | 0.50 | R-38 | R-13 | R-19 | R-6 | R-0 | R-7 |
| ≤25% | 0.46 | R-38 | R-16 | R-19 | R-6 | R-0 | R-7 |

**Replace Tables 502.2.4 (7-9) with:
Table 502.2.4(2)
Prescriptive Building Envelope Requirements, Type A-2 Residential Buildings, Based on Window Area as a Percent of Gross Exterior Wall Area

| % Glazing | Maximum | Minimum | | | | | |
|---|---|---|---|---|---|---|---|
| | Glazing U-factor | Ceiling R-value | Exterior wall R-value | Floor R-value | Basement wall R-value | Slab perimeter R-value and depth | Crawl space wall R-value |
| ≤20% | 0.55 | R-30 | R-13 | R-11 | R-5 | R-0 | R-6 |
| ≤25% | 0.55 | R-30 | R-13 | R-11 | R-5 | R-0 | R-5 |
| ≤30% | 0.47 | R-38 | R-13 | R-19 | R-7 | R-0 | R-8 |

(Reason: This change a) reduces the number of tables to be referenced; b) unifies envelope prescriptive requirements across all areas within the COG, requiring the more restrictive values of zones 5b or 6b; and c) eliminates slab edge insulation requirement.)

**Section 503.3.3.3; amend as follows:
All supply and return-air ducts and plenums installed as part of an HVAC air-distribution system shall be thermally insulated in accordance with Table 503.3.3.3 or where such ducts or plenums operate at static pressures greater than 2 in. w.g. (500 Pa) in accordance with Section 503.3.3.4.1.

(Reason: This change clarifies that requirements for higher pressure ducts are given elsewhere. These duct systems are typically associated with commercially sized equipment. This change will be included in the IECC 2001 Supplement.)

**Section 503.3.3.4; amend subsections as follows:
503.3.3.4.1 High- and medium~~-~~pressure duct systems. All ducts and plenums operating at static pressures greater than 2 in. w.g. (500 Pa) shall be insulated and sealed in accordance with Section 803.2.8. ~~High pressure and medium pressure d~~Ducts operating at static pressures in excess of 3 in. w.g. (750 Pa) shall be leak tested in accordance with ~~SMACNA HVAC Air Duct Leakage Test Manual with a rate of air leakage not to exceed the maximum rate specified in that standard.~~ Section 803.3.6. Pressure classifications

specific to the duct system shall be clearly indicated on the construction documents in accordance with the International Mechanical Code.

503.3.3.4.2 Low pressure duct systems. All longitudinal and transverse joints, seams and connections of ~~low-pressure~~ supply and return ducts operating at static pressures less than or equal to 2 in. w.g. (500 Pa) shall be securely fastened and sealed with welds gaskets, mastics (adhesives), mastic-plus-embedded fabric systems or tapes installed in accordance with the manufacturer's installation instructions. Pressure classifications specific to the duct system shall be clearly indicated on the construction documents in accordance with the International Mechanical Code.

{Exception is unchanged}

(Reason: These changes, which will be included in the 2001 Supplement to the IECC, are necessary because the term "low" and "high" have been discontinued by SMACNA. The modification more clearly delineates the static pressure classification of duct systems in question.)

---

** Section 802.2; Replace blank tables 802.2 (1-4) with the completed tables provided on the following four pages. Delete tables 802.2 (5-37).

(Reason: This change provides a unified set of prescriptive requirements for all areas within the NCTCOG area based upon the most restrictive zone's requirements (5b or 6b). The deleted tables are not necessary after tables 1-4 are completed, and eliminates data irrelevant to the NCTCOG region.)

TABLE 802.2(1)
BUILDING ENVELOPE REQUIREMENTS

| WINDOW AND GLAZED DOOR AREA 10 PERCENT OR LESS OF ABOVE-GRADE WALL AREA | | | |
|---|---|---|---|
| ELEMENT | CONDITION/VALUE (Zones 5B,6B) | | |
| Skylights (U-factor) | 1 | | |
| Slab or below-grade wall (R-value) | R-0 | | |
| Windows and glass doors | SHGC | U-factor | |
| PF < 0.25 | Any | Any | |
| 0.25 ≤ PF < 0.50 | Any | Any | |
| PF ≥ 0.50 | Any | Any | |
| Roof assemblies (R-value) | Insulation between framing | Continuous insulation | |
| | R-19 | R-16 | |
| All-wood joist/truss | R-25 | R-17 | |
| Metal joist/truss | NA | R-16 | |
| Concrete slab or deck | R-25 | R-17 | |
| Metal purlin with thermal block<br>Metal purlin without thermal block | X | R-17 | |
| Floors over outdoor air or unconditioned | Insulation between framing | Continuous insulation | |
| space (R-value) | R-11 | R-6 | |
| All-wood joist/truss | R-11 | R-6 | |
| Metal joist/truss<br>Concrete slab or deck | NA | R-6 | |
| Above-grade walls (R-value) | No framing | Metal framing | Wood framing |
| Framed | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | NA | R-0 | R-0 |
| CMU, ≥ 8 in., with integral insulation | | | |
| R-value cavity | NA | R-0 | R-0 |
| R-value continuous | R-0 | R-0 | R-0 |
| Other masonry walls | | | |
| R-value cavity | NA | R-0 | R-0 |
| R-value continuous | R-0 | R-0 | R-0 |

TABLE 802.2(2)
BUILDING ENVELOPE REQUIREMENTS

| WINDOW AND GLAZED DOOR AREA OVER 10 PERCENT BUT NOT GREATER THAN 25 PERCENT OF ABOVE-GRADE WALL AREA | | | |
|---|---|---|---|
| ELEMENT | CONDITION/VALUE | | |
| Skylights (U-factor) | 1 | | |
| Slab or below-grade wall (R-value) | R-0 | | |
| Windows and glass doors | SHGC | U-factor | |
| PF < 0.25 | 0.6 | Any | |
| 0.25 ≤ PF < 0.50 | 0.7 | Any | |
| PF ≥ 0.50 | Any | Any | |
| Roof assemblies (R-value) | Insulation between framing | Continuous insulation | |
| All-wood joist/truss | R-25 | R-19 | |
| Metal joist/truss | R-25 | R-20 | |
| Concrete slab or deck | NA | R-19 | |
| Metal purlin with thermal block | R-30 | R-20 | |
| Metal purlin without thermal block | X | R-20 | |
| Floors over outdoor air or unconditioned space (R-value) | Insulation between framing | Continuous insulation | |
| All-wood joist/truss | R-11 | R-6 | |
| Metal joist/truss | R-11 | R-6 | |
| Concrete slab or deck | NA | R-6 | |
| Above-grade walls (R-value) | No framing | Metal framing | Wood framing |
| Framed | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | NA | R-0 | R-0 |
| CMU, ≥ 8 in., with integral insulation | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | R-5 | R-0 | R-0 |
| Other masonry walls | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | R-5 | R-0 | R-0 |

TABLE 802.2(3)
BUILDING ENVELOPE REQUIREMENTS

| WINDOW AND GLAZED DOOR AREA OVER 25 PERCENT BUT NOT GREATER THAN 40 PERCENT OF ABOVE-GRADE WALL AREA | | | |
|---|---|---|---|
| ELEMENT | CONDITION/VALUE | | |
| Skylights (U-factor) | 1 | | |
| Slab or below-grade wall (R-value) | R-0 | | |
| Windows and glass doors | SHGC | U-factor | |
| PF < 0.25 | 0.4 | 0.7 | |
| 0.25 ≤ PF < 0.50 | 0.5 | 0.7 | |
| PF ≥ 0.50 | 0.6 | 0.7 | |
| Roof assemblies (R-value) | Insulation between framing | Continuous insulation | |
| All-wood joist/truss | R-25 | R-19 | |
| Metal joist/truss | R-25 | R-20 | |
| Concrete slab or deck | NA | R-19 | |
| Metal purlin with thermal block | R-30 | R-20 | |
| Metal purlin without thermal block | X | R-20 | |
| Floors over outdoor air or unconditioned space (R-value) | Insulation between framing | Continuous insulation | |
| All-wood joist/truss | R-11 | R-6 | |
| Metal joist/truss | R-11 | R-6 | |
| Concrete slab or deck | NA | R-6 | |
| Above-grade walls (R-value) | No framing | Metal framing | Wood framing |
| Framed | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | NA | R-0 | R-0 |
| CMU, ≥ 8 in., with integral insulation | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | R-5 | R-0 | R-0 |
| Other masonry walls | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | R-5 | R-0 | R-0 |

TABLE 802.2(4)
BUILDING ENVELOPE REQUIREMENTS

| WINDOW AND GLAZED DOOR AREA OVER 40 PERCENT BUT NOT GREATER THAN 50 PERCENT OF ABOVE-GRADE WALL AREA | | | |
|---|---|---|---|
| ELEMENT | CONDITION/VALUE | | |
| Skylights (U-factor) | 1 | | |
| Slab or below-grade wall (R-value) | R-0 | | |
| Windows and glass doors | SHGC | U-factor | |
| PF < 0.25 | 0.4 | 0.7 | |
| 0.25 ≤ PF < 0.50 | 0.5 | 0.7 | |
| PF ≥ 0.50 | 0.6 | 0.7 | |
| Roof assemblies (R-value) | Insulation between framing | Continuous insulation | |
| All-wood joist/truss | R-25 | R-19 | |
| Metal joist/truss | R-25 | R-20 | |
| Concrete slab or deck | NA | R-19 | |
| Metal purlin with thermal block | R-30 | R-20 | |
| Metal purlin without thermal block | R-38 | R-20 | |
| Floors over outdoor air or unconditioned space (R-value) | Insulation between framing | Continuous insulation | |
| All-wood joist/truss | R-11 | R-6 | |
| Metal joist/truss | R-11 | R-6 | |
| Concrete slab or deck | NA | R-6 | |
| Above-grade walls (R-value) | No framing | Metal framing | Wood framing |
| Framed | | | |
| R-value cavity | NA | R-13 | R-11 |
| R-value continuous | NA | R-3 | R-0 |
| CMU, ≥ 8 in., with integral insulation | | | |
| R-value cavity | NA, NA | R-11 | R-11 |
| R-value continuous | R-5 | R-0 | R-0 |
| Other masonry walls | | | |
| R-value cavity | NA | R-11 | R-11 |
| R-value continuous | R-5 | R-0 | R-0 |

**Section 805.2.1 Interior Lighting Controls; add a third sentence to read:
Large spaces shall have a separate switch or control for each 2500 square feet of floor area.

(Reason: This change is consistent with energy conservation measures in the 4th public review ASHRAE 90.1 - 1999, Space Control. This "zoning" is especially relevant for after-hours employees in office spaces.)

** Chapter 9; Replace referenced standard as follows:

~~ASHRAE/IES -- 93~~ ~~Energy Code for Commercial and High-Rise Residential Buildings -- Based on ASHRAE/IES 90.1-1989 -- with Revisions thru October 7, 1997 including Errata and Addendum 90.1c-1993~~

ASHRAE/IES -- 99 Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings -- 1999 Edition

(Reason: This adopts the most recent edition of the ASHRAE Standard 90.1 as the reference standard for commercial construction.)

END

## 9.5 Laboratory Response to Proposed NTCOG Amendments to 2000 IECC.

December 21, 2001

Mr. John Promise
Director, Environmental Resources
North Central Texas Council of Governments
P.O. Box 5888
Arlington, TX 76005-5888

Re: NCTCOG Regional Amendments to IRC/IECC

Dear Mr. Promise:

Thank you for your letter of October 11, 2001 requesting that the NCTCOG's recommended regional amendments to the 2000 International Energy Conservation Code and to Chapter 11 of the 2000 International residential Code be reviewed by the Energy Systems Laboratory pursuant to provisions of Senate Bill 5, 77th Texas Legislature (R.S.).

Several items in your recommended amendments will require detailed simulation before we will be able to issue a definitive determination of their impact. We have made progress toward developing a standard tool for these simulations, but anticipate that the process will take several months at least. It has been decided therefore to conditionally approve the NCTCOG amendments package with exceptions noted, and reserving judgment on the items requiring simulation. This means that, with minor modifications as noted, the proposed amendments should result in substantially equivalent energy efficiency results as the unamended codes. If it is determined on completion of our simulations that further minor modifications are needed in order to ensure that amendments do not result in less stringency, we will recommend specific limits at that time.

Items requiring simulation before a final determination of impact include:

IECC

101.3 -- The laboratory will separately review voluntary peformance testing programs to determine whether they meet or exceed the IECC requirements.

302.1 -- Respecting the intent that the overall impact of standardizing the regional requirements (combining zones 5 and 6 into a single zone) be at or above results of the IECC, and recognizing that uniform standards will generally improve compliance by reducing confusion, the laboratory will review whether the impact of increased stringency for zone 5 will exceed the relaxation of the window U-factor for zone 6.

502.1.5 -- The laboratory will review the shading options to determine whether they are equivalent in impact to an average Solar Heat Gain Coefficient of .4 or less for all fenestration products.

502.2 -- The laboratory will review Table 502.2 values to determine whether the standardized values are at least equivalent in impact, overall, to the range of values in the nomographs in this section.

502.2.4 -- The laboratory will review whether the generally increased stringency of prescriptions for zone 5 will exceed limited applications of relaxed window U-factor for zone 6 (up to 12% glazing area).

IRC

N1101.2.1 -- The laboratory will review the proposed air conditioner efficiency trade-offs to determine if these will sufficiently offset the higher levels of glazing as was suggested by MECcheck.

N1102.1 -- The laboratory will review proposed Table N1102.1 to determine additional limitations that may be needed to maintain the code's stringency. For now, we recommend limiting the application of this prescriptive table to projects where the cathedral ceiling area is limited to one third or less of the total ceiling area.

We expect that after simulations have been completed, laboratory determinations on these sections will be positive or that any adjustments needed will be minor.

Exceptions taken include the following:

502.1.1 -- The exception to the requirement for a vapor barrier should be limited to your region, instead of extending to zone 9.

502.2 note g -- The recommendation of equipment inside conditioned space should include "equipment and ductwork." This is not a requirement.

Chapter 9 -- ASHRAE Standard 62-1989 has been replaced by 62-1999 (Ventilation for Acceptable Indoor Air Quality), and this reference should be updated along with 90.1.1999.

Sincerely,

Tom Fitzpatrick
Energy/Codes Specialist

cc: Pat Baugh, Chairman-RCCC; Russ Mower, Chairman-BECAB; Kenny Calhoun, NCTCOG; Bahman Yazdani, ESL; File: SB5/IECC Amendments/NCTCOG